S. HRG. 100-836

IMPACT OF ACID RAIN ON COASTAL WATERS

HEARING

BEFORE THE

NATIONAL OCEAN POLICY STUDY

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

SECOND SESSION

ON

THE IMPACT OF ACID PRECIPITATION ON COASTAL WATERS AND REAUTHORIZATION OF TITLE III OF THE MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

JUNE 8, 1988

Printed for the use of the
Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

89-273 O WASHINGTON : 1988

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

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IMPACT OF ACID RAIN ON COASTAL WATERS

WEDNESDAY, JUNE 8, 1988

U.S. SENATE,
SUBCOMMITTEE ON NATIONAL OCEAN POLICY STUDY,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The subcommittee met at 9:30 a.m., in room SR-253, Russell Senate Office Building, Hon. John F. Kerry presiding.

Staff members assigned to this hearing: Mike Nussman, professional staff member and Bob Eisenbud, minority professional staff member.

OPENING STATEMENT BY SENATOR KERRY

Senator KERRY. This hearing will come to order.

I am delighted to welcome our various panelists, also my colleague Senator Mitchell, whose interest and leadership on this issue has been significant for a long period of time. I share with my colleague from our neighboring state a very deep-rooted interest in this issue.

I had the privilege of serving, in my capacity as Lieutenant Governor to Governor Dukakis, as his appointed surrogate on the National Governors Task Force on Acid Rain, and for a period of time met with Governor Lamb, Governor Rockefeller at the time, Governor Sununu, and others in trying to devise a national plan on acid rain.

I also served, again as a surrogate for Governor Dukakis, as the chairperson of the New England Governors Task Force on Acid Rain. And during the course of that time, we put together a program, which I am pleased to say passed the National Governors Association unanimously, which did involve a cost-sharing approach to the whole question of a 48-state, contiguous state, cleanup plan.

What is interesting is that during the course of that time I traveled to Scandinavia and to Germany, Belgium, and other countries, to view what had happened there. I saw enormous damage in Norway and Sweden. I became very familiar with their acid rain mitigation programs, which included liming in the lakes and other efforts.

I visited the Black Forest in Germany and saw first-hand the devastation there, and the worsening ambient air quality caused in part by sulphur dioxide emissions.

Now, in the course of all of those studies, none of us thought about sulphur and nitrogen oxides, contributing to problems in a salt water, in the ocean, and in bays and estuaries.

And suddenly, thanks to the Environmental Defense Fund and their study, there is now a new awareness of the possibility, that coastal waters may also be impacted as a result of acid rain.

We have heard from experts nationally on many different areas, but obviously this new threat is one that has to be taken seriously and which may add some impetus to the efforts of Senator Mitchell and others to try and move on the Clean Air Act, and particularly on an acid rain mitigation program.

I would like to applaud the efforts of the Environmental Defense Fund for their leadership on this. I do know that some aspects of the study are still, subject to some question. It is the purpose of this hearing to try to have an airing of all views regarding the data and the methodology, in order to try to understand better what is happening.

In the past, we have always been focused much more on the SO_2 aspects of acid rain. But it appears evident now that the NOx aspects of acid-rain may be something that we need to pay more attention to and in fact we may need to conceivably think about raising the levels of NOx reductions in connection with our approach to the sulphur dioxide issue. The relationship between the added amounts of nutrients that are flowing into bays and the ability of that added amount of nutrient to add to the growth of algae, which in turn choke off oxygen, kill fish, restrict growth, and effect shellfish needs to be understood.

What this hearing is really about, is getting a handle on this report, which concerns an issue that we are just learning about. Clearly, as a Senator from a state which boasts great portions of our national seashore and a number of bays, including Buzzards Bay and others, and which, thanks to our commercial fishing ports has a very important relationship with the ocean, this issue is something of significant concern to us.

And it ought to be, obviously, whether or not you have those assets directly at your availability. It ought to be of concern simply as a matter of conservation and preservation of the fragile natural resources that we are blessed with.

So I am looking forward to the testimony today. I hope during today's hearing that we are going to keep in mind how long it has taken to get any kind of progress, to get clear evidence of environmental damage.

What I have learned about the effects of acid rain, whether it is on crops or forests or statues or human health by the increased acidity and the ability to leach lead from pipes and other minerals into water and so forth raises the level of concern that we already have about our ability to protect ourselves in the long run.

Clearly, this report has now raised a number of new questions. I think they are significant and I look forward to hearing from all of our panelists today to examine where we are, where we ought to be going, how this does or doesn't contribute to the current dialogue, and whether or not this will in fact assist us in trying to devise an approach to what I think is a very, very important national issue.

The Chairman, Senator Hollings, has an opening statement that I will insert in the record at this point.

[The statement follows:]

OPENING STATEMENT BY THE CHAIRMAN

Good morning. Today the National Ocean Policy Study and the Commerce Committee will review the recent Environmental Defense Fund report, Polluted Coastal Waters: The Role of Acid Rain. In addition, we will hear testimony on the reauthorization of the National Oceanic and Atmospheric Administration's Marine Sanctuary Program.

One of the most controversial air quality issues in recent years has been what to do about acid rain. Until last month, the debate centered on understanding what impact acid deposition had on freshwater systems, forests, and crops. However, on April 25, the Environmental Defense Fund (EDF) released their study on the threat that acid rain poses to marine life in the Chesapeake Bay and other coastal waters. The EDF report asserts that acid rain, by acting as a fertilizer, can have a serious effect on coastal waters. In excess, nutrients, such as the nitrogen found in acid rain, can cause algal blooms which in turn can suffocate marine life.

The EDF study maintains that 25 percent of total nitrogen coming into the Chesapeake Bay results from acid precipitation. While, I understand the uncertainties that surround this estimate, I believe that considering the impact that excess nutrients can have on coastal water quality, we must begin to focus the necessary resources on this problem.

After we complete our examination of the impact of acid rain on coastal waters, the Committee intends to review NOAA's National Marine Sanctuaries Program. In 1972, we enacted this program in response to concerns about the increasing degradation of our marine environment. The program provides for the protection of important marine areas through the establishment of marine sanctuaries. To date, seven sanctuaries have been established around the nation.

I welcome the witnesses here today and look forward to their testimony.

Senator KERRY. Senator Mitchell?

STATEMENT OF HON. GEORGE J. MITCHELL, U.S. SENATOR FROM MAINE

Senator MITCHELL. Thank you very much, Mr. Chairman. I commend you for holding this hearing, for the leadership you have demonstrated in this area over the past several years, both as Lieutenant Governor of Massachusetts and as a Senator from that state.

It is obviously an issue which concerns all of us, not just those of us from New England, but people throughout the country.

Seven years ago when I introduced the first acid rain control legislation, I said that more than 170 lakes and ponds in New York State no longer support life. The acidity of Maine lakes has increased eightfold in the past 40 years, and forest growth may have been retarded in Sweden, all as a result of acid deposition.

Some argued in response that the effects of acid precipitation were at most limited, and in any event uncertain.

At the beginning of this administration, the call was for more research to determine whether or not there is a problem. Over the past seven years, there has been more research, much more research. It has confirmed the existence of the problem and the need for action to deal with it.

Last year, some of the leading public health officials in this country, representing the American Public Health Association, the American Lung Association, the American Academy of Pediatrics, and the Mount Sinai Hospital Department of Environmental Medicine, all testified unanimously before the Subcommittee on Environmental Protection that in their opinion acid rain should be controlled on the basis of health considerations alone.

That is, if there were no demonstrable damage to natural resources of any kind, that the adverse effects on health are sufficient to justify action.

A Harvard researcher testified: "In every epidemiologic investigation that we have performed over the past six years, we have repeatedly found a two to five percent air pollution effect on human mortality and morbidity."

I do not represent that as a fact, because I do not know if it is a fact. It is the statement of one researcher in the field. If it contains even a germ of truth, it should alarm every American and shock us all into action.

The American Forestry Association in 1987 said:

> Given the importance of forest, aquatic, and terrestrial resources to the health and well-being of the nation, the American Forestry Association believes that the risks and costs associated with further delaying additional pollution controls now seem to outweigh the risks and costs associated with action.
>
> AFA therefore recommends that Congress amend the Clean Air Act to significantly strengthen control of sulphur dioxide, nitrogen oxides, hydrocarbons, and if feasible toxic metals. The control programs should target the nation as a whole, as the terrestrial and aquatic forest impacts from air pollution constitute a national threat.

Recently released Environmental Protection Agency data suggests that there may be over 25,000 fresh water streams in this country at risk from acid deposition. This national stream survey states that acid deposition cannot be ruled out as a major source of acidity in these streams.

Today this committee will listen to more experts discuss still another study that indicates that coastal waters are being adversely affected by acid rain. The study by the Environmental Defense Fund indicates that 25 percent of the nitrogen oxides deposited in the Chesapeake Bay are from acid rain.

And although experts may not all agree on the precise percentage, the fact that acid rain impacts our coastal waters is a significant fact.

The years of additional research have produced a steady drumbeat of data leading to one inevitable conclusion: Acid rain is damaging American lakes, streams, coastal waters, and forests. And most importantly, it is damaging the health of Americans.

We have studied and we have waited, and the studies have shown that we have waited long enough. It is now time for action.

Mr. Chairman, I regret that I have to go to another hearing in the Environment Committee this morning, so I will not able to stay for the whole hearing. But I look forward to reviewing the testimony of the witnesses, both of whom have testified before our committee on a many occasions, and I know they will be providing this committee with a great deal of valuable information.

Senator KERRY. Well, thank you very, very much, Senator Mitchell. Again, I really want to thank you.

The first time you and I ever met, as a matter of fact, was in New Hampshire at an acid rain conference where you were the keynote speaker. And you have really been terrific in your leadership on this.

And I know that when we get legislation, it is going to be largely due to your efforts. And I thank you for joining us here today.

I might just introduce into the record an article from the May 2 "Baltimore Sun," in which it notes that: "The EPA upgrades the acid rain risk to the East Coast. 'And the draft report on the survey by the EPA suggests that there was a significant number of acidified streams in the Middle Atlantic coastal plain, stretching from New Jersey to North Carolina, particularly in the Chesapeake Bay and New Jersey areas and in the northern Appalachian plateau of West Virginia, Pennsylvania, and New York. And this will be made part of the record.

[The article referred to follows:]

[From the Baltimore Sun, May 22, 1988]

EPA Upgrades Acid-Rain Risk to East Coast

CHESAPEAKE BAY AMONG AREAS OF INCREASED CONCERN

WASHINGTON—A survey of streams in the Eastern United States by the Environmental Protection Agency show that the acidification of fresh water is much more widespread than was previously known.

A draft report on the survey said that there was a significant number of acidified streams in the Middle Atlantic coastal plain stretching from New Jersey to North Carolina, particularly in the Chesapeake Bay and New Jersey areas, and in the northern Appalachian plateau of West Virginia, Pennsylvania and New York

The report said that about 4.4 percent of the 66,000 miles of stream in the Middle Atlantic survey area were acidic and that roughly half the streams in the area were found to have a potentially low capacity to neutralize acid rain.

The survey was based on a sample of about 500 streams and was made available to the *New York Times* by agency officials.

Previous surveys by the agency found serious acidification only in several hundred lakes in New York state's Adirondack Mountains and in parts of New England. The damage to the lakes there was widely attributed to acid rain caused chiefly by air pollution traveling from as far away as the Midwest.

EPA officials noted that the survey was not designated to establish a cause-and-effect relationship between acid rain caused by pollution from coal-burning power plants and other industrial sources and the acid content of Eastern streams. But several key officials said the results of the survey were a clear indication that the damage acid rain causes to surface waters was being seen in large parts of the Eastern United States.

"What we are seeing here is a fully documented, statistically designed survey showing a broader geographical extent of environmental effects from acid rain that we previously realized," said Courtney Riordan, director of the Office of Environmental Processes and Effects Research.

He added that finding more than 4 percent of the streams acidic in the Middle Atlantic region was significant because "we could be in a dynamic situation—we may be just at the tip of what is going to happen."

The survey found relatively few acidified streams in the Southeast. But it also found that half the streams in that area had a low alkaline content, making them susceptible to future problems.

About 12 percent of the streams in Florida were found to be acidic, but the cause was primarily natural organic substances in the water and sediment, rather than pollution, the survey said.

Acid rain consists chiefly of oxides of sulfur and nitrogen emitted by coal-burning power plants, smelters, factories and motor vehicles. These oxides are changed chemically in the atmosphere and fall to earth as acidic rain, snow, fog or dust.

Many scientists believe that acid rain is destroying plant and animal life in sensitive bodies of fresh water and that it may also play a role in damaging forests, man-made structures and perhaps human health.

Amendments to the Clean Air Act, including changes that would require a major effort to reduce acid rain, are pending in the House and Senate. Environmentalists said that the new EPA report on the acidification of Eastern streams underscores the need for mandatory controls to reduce the pollution that causes acid rain.

Robert A. Beck, assistant director for environment and fossil fuels at the Edison Electric Institute, an association of investor-owned electric utility companies, said that the new study did not demonstrate any need for legislation to control pollution from power plants or other sources.

Mr. Beck said the institute "is comfortable that the sampling procedures are accurate."

But he said that the survey did not prove the cause of acidification and that even if the source was sulfur dioxide, this did not suggest that the situation was worsening. He said rotting leaves and other natural organic matter also could be causing the acidity.

Dixon Anders, aquatic team leader of the EPA laboratory in Corvallis, Ore., which conducted this survey and other studies on the acidity of U.S. lakes and streams, said that while some acidification of fresh water was a result of natural causes, research had shown that pollution caused by human activity made such streams worse.

Senator KERRY. We obviously look forward to the continued efforts of EDA to understand this problem.

Now, I would like to turn to the first panel. As Senator Mitchell said, they have testified often and with a significant contribution to the dialogue: Dr. Diane Fisher of the Environmental Defense Fund and Dr. Michael Oppenheimer. We are delighted to welcome both of you.

STATEMENT OF DR. MICHAEL OPPENHEIMER, ENVIRONMENTAL DEFENSE FUND

Dr. OPPENHEIMER. Mr. Chairman and Senator Mitchell: Thank you for this unusual opportunity to present the results of our study to the members of the Congress.

We believe that our findings bear important implications for the acid rain control program which the Congress must ultimately design. Our findings also bear directly on the national acid deposition assessment program and that program's future initiatives.

Before I turn the microphone over to Dr. Fisher, I would like to describe briefly the origins of this study. In 1985 the Environmental Defense Fund undertook a study of the effects of acid rain on the New York City drinking water supply system.

We discovered a trend in nitrate levels in that system, which we associated with the increases in nitrogen oxide emissions from fossil fuel combustion in the eastern United States.

Subsequently we discovered, through examining studies by the U.S. Geological Survey and others, that the trend of increasing nitrate in surface waters and the association with emissions of nitrogen oxide had been identified by other investigators and was rather broadly observed across the whole eastern United States.

At that time, a study by Professor Hans Paerl of North Carolina, who I believe is going to testify later, came to our attention. Dr. Paerl noted that nitrate could play an important role in generating enhanced productivity in coastal waters off the Outer Banks of North Carolina.

At the same time, we came across a study by Dr. David Correll of the Smithsonian Institute's Research Station on the Chesapeake Bay, which noted that nitrate from the atmosphere contributed significantly to the nitrogen budget of one of the sub-estuaries of the Chesapeake Bay.

So this study was not born in isolation. We also discovered shortly thereafter some studies from the Baltic in Northern Europe, the Baltic Sea, which indicated that atmospheric inputs made a significant contribution to the nitrogen budget and the eutrophication problem in that sea as well.

Of course, it has been well known for several years that nitrate is an important nutrient which feeds algae blooms in coastal waters, and in fact in many coastal waters is the limiting nutrient.

So back in 1985, we posed to ourselves the following question: Does atmospheric nitrate deposition originating in fossil fuel combustion, a component of acid rain, make an important contribution to the eutrophication of coastal waters and their associated biological decline?

The study commenced in 1986. Dr. Fisher has been chiefly in charge of working that study, and she will tell you something about the details now and some further work we have done since the study was published.

STATEMENT OF DR. DIANE FISHER, ENVIRONMENTAL DEFENSE FUND

Dr. Fisher. Thank you.

I would like to thank Senator Kerry, Senator Mitchell, and this committee for the opportunity to speak today. My name is Dr. Diane Fisher. I am a chemist and a staff scientist with the Environmental Defense Fund, a private non-profit organization.

My work with EDF has focused primarily on the effects of acid rain. I am here today to share with you the results of a two-year study by four EDF scientists, including myself and my co-panelist, Dr. Oppenheimer. This was published recently in the report, "Polluted coastal waters: the role of acid rain."

The study should transform our view of the acid rain problem. Our analysis shows that acid rain is not just a threat for fresh water lakes and fish; it is contributing to the decline of our coastal waters as well. Atmospheric nitrate deposition, a component of acid rain, is an important source of the nutrient nitrogen to the Chesapeake Bay and other coastal waters.

We calculate that acid rain contributes 25 percent of the nitrogen from human activities which enters the Chesapeake, making it second only to fertilizer runoff as a source of anthropogenic nitrogen to the Bay.

Since publishing our report, we have had the opportunity to do calculations which test the effect of the uncertainties in some of our underlying assumptions. We find that our estimate is very robust. When we vary some of these assumptions—and I have described this in more detail in the supplemental document submitted to this committee—we calculate a range of from 21 to 32 percent for the contribution of acid rain to nitrogen in the Chesapeake Bay. We consider 25 percent to be our best estimate.

Preliminary analyses for the Long Island Sound and for the Neuse River basin, an estuary in North Carolina, indicate a similar role for acid rain.

Our eastern coastal waters are receiving enormous inputs of nutrients, especially nitrogen and phosphorus. In most cases, production of algae in marine ecosystems is limited by nitrogen inputs. Adding more nitrogen is like spreading fertilizer on the water.

It causes the growth of too much algae, which uses up oxygen and blocks sunlight, making it difficult for other marine life to survive. This is especially harmful to organisms which live on the bottom of the water, such as oysters, clams, crabs, and lobsters, since they cannot swim away and suffocate as the oxygen is used up.

Some forms of algae are also directly toxic to fish, and others are directly harmful to underwater plants. Both the toxicity and the oxygen depletion from algal blooms lead to massive kills of aquatic organisms. Large portions of our estuaries are becoming dead seas, unable to support the life that once flourished there.

Obviously, this has very important economic implications. The value of commercial and recreational fishing in the Chesapeake Bay region has been estimated at nearly one billion dollars, and nationwide these activities generate $10 billion.

This is only one of the many industries which depend critically on water quality in our coastal zones, tourism being another obvious example.

Most of the previous studies of nitrogen inputs to coastal waters have either ignored or seriously underestimated the role of acid rain. Those studies which looked at atmospheric inputs at all only looked at the amount of nitrogen in wet precipitation falling directly into the body of water in question.

This is only one of the pathways by which atmospheric nitrate reaches coastal waters. Two other important routes are dry deposition in the absence of rain and runoff of atmospheric nitrate which falls on the land surrounding the water.

Most of the atmospheric nitrate which falls on the land is taken up by trees and other vegetation. But a fraction also washes into rivers, which then drain into the bay. Even studies which ignore these two pathways often show large nitrogen inputs from atmospheric nitrate.

For instance, the study which Dr. Oppenheimer referred to by Dr. Correll at the Chesapeake Bay Center for Environmental Studies of the Smithsonian Environmental Research Center concluded that wet deposition of nitrate alone was contributing 19 percent of the nitrogen in the Rhode River estuary.

We calculated the nitrogen loading to the Chesapeake Bay from atmospheric nitrate as follows. First, we got data from the national atmospheric deposition program to calculate the nitrogen in wet deposition falling on the watershed. Published values for dry deposition, including the latest data from the National Acid Precipitation Assessment Program dry deposition monitoring network, show that this form of atmospheric nitrate deposition contributes from one to four times as much nitrogen as wet deposition.

We therefore made the relatively conservative estimate that dry deposition is approximately equal to wet, and this is one of the assumptions that I varied in our sensitivity studies. And we find that when you vary you get somewhere between 21 and 32 percent for the acid rain contribution.

We estimated the amount of atmospheric nitrate falling on land type which would run off into the bay for each land type. For instance, we assumed that 90 percent of the nitrogen and atmospheric nitrate which falls on forested land is taken up either by the trees or by processes in the river.

We took care to differentiate between nitrogen in atmospheric ammonium, which originates largely from agricultural sources, and nitrogen in atmospheric nitrate, which originates from fossil fuel combustion.

We obtained data on the other sources from the EPA Chesapeake Bay Program and from state agricultural agencies. We calculate that atmospheric nitrate deposition contributes a full 25 percent of the nitrogen entering the Chesapeake Bay, and causing the eutrophication problems there.

Preliminary estimates for the Long Island Sound and the Neuse River in North Carolina indicate more than 20 percent of the nitrogen in these waters is coming from acid rain. We have therefore identified an important source of nitrogen to estuaries which has previously been largely ignored.

Large reductions in nutrient inputs to coastal waters are necessary if we want to halt their deterioration. EPA and the Chesapeake Bay states have established goals of 40 percent reduction of phosphorus and nitrogen inputs, and similar goals have been recommended for the Neuse River. Progress has been made on phosphorus inputs and further reductions are planned.

Reductions of nitrogen inputs from agricultural runoff and point sources have also been proposed, and we support these measures. However, if we ignore the large inputs of nitrogen from acid rain, not only will these reduction goals not be reached, but nitrogen reductions from other sources will be largely undone as this source continues to grow.

The sources of nitrate in acid rain are emissions from motor vehicles, power plants, and factories. If left uncontrolled, these emissions are projected to increase by 40 to 60 percent over the next four decades. In this case, acid rain will become the major manmade source of nitrogen to the Chesapeake Bay.

We recommend that nitrogen oxide emissions be cut by 40 percent to parallel planned reductions in other sources of nitrogen to the Chesapeake Bay. This reduction will also benefit the Long Island Sound, the Neuse River, and all other East Coast waters which are currently overloaded with nitrogen.

A Federal role is absolutely essential to accomplish this. Most of the acid rain falling on coastal states originates from other states upwind. The first step to control this problem is reauthorization of the Clean Air Act with strong controls on acid rain precursors.

Energy efficiency measures, technology retrofits for existing stationary sources, and advanced boilers and stack and tailpipe technologies on new sources can reduce nitrogen oxide emissions by the necessary amount. Energy efficiency has the advantage of also cutting sulphur dioxide emissions.

Reductions in these emissions would also result in decreased acidification of fresh water lakes, decreases in costly damages to structural materials, decreased nitrates in drinking water, and decreased air pollution from ground level ozone, a component of urban smog which causes lung damage at levels currently observed in most major cities in the United States.

If such measures are not implemented, our eastern coastal waters will continue to decline.

Thank you.

Senator KERRY. Thank you very much, Dr. Fisher.

I have been joined by my colleague Senator Stevens from Alaska. Do you want to make any kind of opening comment?

[No response.]

Senator KERRY. Let me just make one comment, and I mentioned this earlier, that it has been brought to our attention recently that European and Scandinavian countries are reporting similar findings of excessive high nitrate levels in their ocean waters, and they too have become increasingly concerned.

I would like to ask you both, and you can share the answers if you want, is there a general agreement in the scientific community about the high level of nitrate being to blame for the increase in algae, et cetera?

Dr. FISHER. Well, I think that there is a widespread consensus in the scientific community that nitrogen is a problem in coastal waters and that it is contributing to the growth of algae there. And any form of nitrogen that enters the water, either from nitrate or from fossil fuels or any other source of nitrogen to the waters, will contribute to that problem.

Senator KERRY. Now, how do you separate and make the determination between the amount of wet deposition that will have an impact and the amount of dry deposition that will have an impact?

Dr. FISHER. Well, we separated the contributions. We looked at both wet and dry deposition directly to the water, and obviously both of those will have an impact because they are going directly into the bay.

Senator KERRY. But how much, for instance, of the dry? I mean, in order to run off there is going to have to be a rainfall.

Dr. FISHER. Right.

Senator KERRY. There is going to be a certain amount of distance, is there not, that some will travel?

Dr. FISHER. And some of that is taken up. A lot of the nitrogen from acid rain and from other sources—fertilizer input, animal wastes—a lot of that nitrogen is taken up by surrounding vegetation and other processes before it gets into the water.

And the way we estimated how much would be taken up and how much would get into the water is we looked at scientific studies that have been done in watersheds that estimate how much of the nitrogen going into the watershed is taken up by vegetation and how much gets into the water. And we based our estimate of how much is taken up by vegetation and how much gets into the water on those studies.

Senator KERRY. Now, to what degree does that vary according to the particular vegetation or particular soil system that you have around the Chesapeake Bay?

Dr. FISHER. Well, it varies according to land type. Generally, forests take up more of the nitrogen; croplands take up less as a percentage. And that is something that we accounted for in our calculations.

Also, the calculations I mentioned that are described in the supplemental material that we have submitted look at the effect of varying our assumptions about how much nitrogen is retained and how much runs off into the water.

Senator KERRY. So you have a worst case assumption, sort of least retention and maximum retention?

Dr. FISHER. Yes. But remember that any uncertainty in how much nitrogen is retained by the terrestrial system applies not just to the acid rain contribution, but to all the other sources as well.

And the important finding of our study is that acid rain is a big part of the nitrogen budget relative to the other sources. And you can vary your assumptions about how much nitrogen is taken up by the terrestrial ecosystems by a lot and, if you have more retention of acid rain nitrogen, you will also have more retention of fertilizer nitrogen, for instance.

So it does not change the relative importance of acid rain to the other sources by all that much.

Senator KERRY. To what degree of certainty do you know the quantity of nitrate that's entering into the bay itself, both wet and dry?

Dr. FISHER. Well, the total amount of nitrogen going into the bay varies by a lot from year to year, and you expect that to be true of the acid rain nitrogen as well. But I do not know. I guess——

Dr. OPPENHEIMER. The major difference in the work that has come out of the EPA is that the amount of nitrogen going into the bay varies depending on whether it is a wet year or a dry year.

And the amount goes up by about a quarter to a third and goes down by about a quarter to a third, depending upon whether it is a wet year or a dry year. But again, all the sources of nitrogen are affected by that same variability.

Senator KERRY. Assuming it is a dry year, low rainfall, you make a statement, do you not, about the degree to which that impacts, correct?

Dr. OPPENHEIMER. We tried to focus our investigation on the typical year, the average year.

Senator KERRY. Now, how do you arrive at that? Just based on long term weather history?

Dr. OPPENHEIMER. Long term data, precipitation rates. Long term data is now available on acid rain precipitation rates. We have been monitoring it since 1977, so it has been possible to get sort of an average picture.

And it is also worth noting that, again, many of the other sources are affected by the same changes that acid deposition is when the amount of precipitation changes. Things like leaching rates also depend on precipitation rates.

So we think again, as Dr. Fisher said, that the calculation is rather robust. We have tried to play with it and get the numbers both up and down by a significant amount, and it is not possible to do with any reasonable set of assumptions.

Senator KERRY. What do you say to somebody who asserts that you have not really watched it for long enough, that you need a longer control period?

Dr. OPPENHEIMER. Certain studies have been done on the bay for a long time. For instance, we know that the biological condition of the bay has gotten worse over several decades.

We know the level of nitrogen deposition has increased in this part of the United States since the early 1960's. There is some data from that early. We know that there has been a trend in nitrate going into the bay from the rivers that dump into the bay over several years.

So there are studies which go back a number of years. What you have to remember is that this finding fits into a consistent pattern. And this goes back to the first question you asked. It is a consistent pattern, not only here but in Europe, of increasing nitrate, not only in surface waters but in coastal waters.

And if you will allow me, I have a study here which just came to my attention yesterday. It is a draft study put out by the Economic Commission for Europe, based on a workshop that occurred in Scandinavia a few weeks ago actually. Let me quote:

"Direct atmospheric deposition, as well as leaching from terrestrial systems caused by atmospheric deposition, contributes significantly to the total nitrate input to many of the affected marine ecosystems."

They were talking about the Baltic and other European ecosystems. So there is no question that this is an effect which has been identified by other scientists in other places.

What we did is put together a quantitative picture of what is going on on one well-studied estuary.

Senator KERRY. Some prior studies have asserted that pesticides, herbicides, heavy metals, other things have been the cause of the deterioration of the Chesapeake. How do you distinguish between their impact and the nitrate impact?

Dr. OPPENHEIMER. In the broader biological sense, I think it is very difficult to distinguish between impacts. You have to look at specific species, specific episodes, specific biological changes.

And what you can say is, I think, that eutrophication is part of a broader picture and that nitrate is an important, perhaps the critical factor encouraging eutrophication in these marine waters.

Senator KERRY. Can one classify the nitrate problem as the most serious problem facing the bay? Or is it just one of several? Or is it a mistake to even place it on a relative scale?

Dr. OPPENHEIMER. By the way, I used the word "nitrate" a minute ago in the wrong sense. I meant total nitrogen.

The total nitrogen problem has been identified by EPA as one of a few problems which is critical for the health of the Chesapeake Bay. And if the studies were being done—and they are not, unfortunately—I am sure it would be so identified for other coastal waters of the eastern United States.

The nitrate from the atmosphere fits in as a big chunk of that very important problem.

Senator KERRY. That is the 25 percent?

Dr. OPPENHEIMER. 25 percent. So the way I look at it is, this is a big chunk, but not the only chunk, of a very important problem, and that makes it very important. Not only that, it is about as big as any other part of the problem.

Dr. FISHER. And it is important to note that that chunk is going to grow if we do not do something to control it. In the absence of further legislation, that chunk is going to grow by 40 to 60 percent over the next four decades.

Senator KERRY. Now, your report makes it clear that there are important gaps in our knowledge of what happens to nitrogen in the environment. What areas of research do you think need to be emphasized if we are going to have a clearer picture of the effect of acid rain?

Dr. OPPENHEIMER. I think that substantial resources need to go into a long term biogeochemical research program on the role of nitrogen in terrestrial ecosystems, how it interacts with the atmosphere, how it moves through the system into coastal waters.

That is a serious program that will cost a lot of money. It has fingers into other things the Federal Government should be worried about, like the climate change problem, like the viability of ecosystems across the United States. And it is time that we had a long-term research program in this country which dealt with those issues.

I think we are at a juncture where a set of environmental problems, not just acid rain or nitrate deposition, but others such as climate change, are coming together, and the synergistic consequences of all those changes are going to overburden our ecosystems in the near future.

The only way to get ahead of that problem is to invest in research now in a big way.

Senator KERRY. Let me turn to my colleagues. Senator Stevens?

Senator STEVENS. Yes. Thank you very much, Mr. Chairman.

Dr. Fisher, you made some interesting comments. Let me ask you this. How much of this nitrogen in the Chesapeake Bay do you think comes from runoff and how much from acid rain?

Dr. FISHER. Well, first of all, you have to realize that some of the nitrogen in runoff ultimately comes from acid rain, and we have included that in our calculation.

Senator STEVENS. In which side of the column?

Dr. FISHER. Excuse me?

Senator STEVENS. You have included it. Where is it showing up, in the runoff or on the acid rain side?

Dr. FISHER. Acid rain contributes to the runoff, and so we have looked at both the acid rain going directly into the water and the contribution of acid rain to the runoff. And when you add all those together, you get 25 percent for those contributions.

Senator STEVENS. But I am trying to separate them. How much comes from runoff in the coastal states and how much comes from acid rain?

Dr. FISHER. Okay. Out of the 25 percent, I believe about eight percent is from direct rainfall into the water itself, and so the rest, about twice as much, would be coming from acid rain contributing to runoff.

Senator STEVENS. You say that most of the acid rain falling on coastal states originates from other states upwind. That is from your statement.

Dr. FISHER. That is right.

Senator STEVENS. What states are those upwind? Is it New England, Canada? Is it just the Middle Atlantic states?

Dr. OPPENHEIMER. If you look at the sources of nitrogen—sources of atmospheric nitrate deposition in any state in the Atlantic coastal plain, there is generally two sorts of contributions: the local contribution, which tends to be heavily from mobile sources, automobiles for instance; and a distant contribution, which would tend to come more heavily from electric power plants.

And there has not been a good, very accurate calculation of that source attribution. But my own estimate would be for the Chesapeake Bay watershed about half of the nitrate being deposited from the atmosphere is fairly local and relates largely to mobile sources; about half is transported from a distance, some of it from the Ohio basin states for instance, where coal-burning electric power plants produce significant amounts of nitrogen oxides.

So we have several sources.

Senator STEVENS. That is what I am trying to find out. What does "upwind 'really mean? Does it mean Northeast?

Dr. OPPENHEIMER. It would mean primarily Ohio, Illinois, Indiana, Kentucky, West Virginia, Virginia, Tennessee. It would not be Alaska, for instance.

Senator STEVENS. No, we just have all of the places set aside to protect the country, but we do not have acid rain. We do have 70 percent of all the wilderness, 80 percent of all the national parks and wildlife refuges in the nation.

Everyone in the East, when they want to feel good about being an environmentalist, sets aside another piece of my state. Meanwhlle, they do nothing about their part of the country. That is what I am trying to get to right now.

Senator KERRY. We would be glad to give you a few power plants.

Senator STEVENS. We have tried that, but people set aside the areas as wilderness so we cannot build them. But they continue to build them down here, where you have so much acid rain and so many problems.

I would like to get to the question as to how far out from Chesapeake Bay would we impose these controls that you have mentioned, Dr. Fisher, controls I support incidentally, on acid rain precursors?

You said the first step to control this problem is reauthorization of the Clean Air Act with strong controls on acid rain precursors. Now, that really does not get to the first part, to the runoff, does it?

Dr. FISHER. Yes, it will, because the acid rain which is falling on the land contributes to the runoff, and that acid rain is coming both from local and from far-away sources.

Senator STEVENS. But again I am talking about the runoff that is not acid rain-originated. I am talking about the runoff that comes from pesticides, et cetera. The land-based runoff into the Chesapeake Bay is not going to be controlled by the Clean Air Act. Maybe the Clean Water Act, but not the Clean Air Act.

Dr. FISHER. We do discuss the other sources of nitrogen to the Chesapeake Bay, and we are not proposing that only the acid rain component be controlled. There have been proposals to control nitrogen from sewage treatment plants and from agricultural runoff, and we support those proposals.

We believe that you are going to have to control all of these sources to a significant extent to get the kind of reductions needed, a 40 percent reduction in nitrogen input to the Chesapeake Bay that has been called for.

Also, as I mentioned, although we focused on the Chesapeake Bay, we have taken preliminary looks at some other coastal waters, and we believe that this problem will exist all up and down the eastern coast, not just for the Chesapeake Bay.

Senator STEVENS. It appears to me in my time here that the Chesapeake Bay has just gone downhill, downhill, downhill, and it is not far from dying. But we keep saying only the Federal Government can save it. Your statement says that again.

Your statement says the coastal states can begin this job on their own, but a Federal role is absolutely essential to finish the job.

Dr. FISHER. That was referring specifically to the acid rain contribution to this problem. It is true that the states can begin to control some of the other sources on their own, and we think that they should do that.

But in order to control the acid rain component, you are going to have to have some kind of Federal role, simply because most of the acid rain nitrogen is not coming from the states around the Chesapeake Bay; it is coming from states further away.

Senator STEVENS. I just wonder why we should not get a further Federal authorization for the states in this area to get together and take whatever action is necessary to save the bay.

I have been sitting here now for 17 years and nothing has really been done to save the bay, in my judgment. It is just getting worse. And everybody comes every year and says: Why does not the Federal Government do some more about it? We passed a series of laws we thought were going to do something about it, but they have not done it.

Have you all explored the concept of a regional control that really would be strong and could in effect put in whatever interstate compact or whatever they needed to control some of these things you are talking about?

Dr. OPPENHEIMER. I think a regional program—and in a sense, one is already under way under the aegis of EPA, and that program is dealing with agricultural runoff. It is dealing with sewage treatment, effluent, more with phosphorus than with nitrogen however.

Senator STEVENS. You are really not talking about a program that costs a lot of Federal money. You really want Federal controls, do you not?

Dr. OPPENHEIMER. That is right. But a state compact of the states bordering the bay cannot solve this part of the problem, the atmospheric part.

Senator STEVENS. Why?

Dr. OPPENHEIMER. Because most of the atmospheric nitrogen appears to originate outside those I think six states which directly border the bay. It comes from elsewhere, and without a little prodding from the Federal Government it is hard to see how, say, Ohio is going to want to reduce its nitrogen emissions for the sake of the Chesapeake Bay.

It could happen, but I would doubt it.

Senator STEVENS. Well, I think it is time for those six states to make a deal with the rest of the country to take the action they can take to the absolute utmost of their exertion and then prove to the Federal Government that the Federal Government ought to go beyond the six states.

Those six states are not doing much right now.

Dr. OPPENHEIMER. I would agree with you that those six states ought to immediately consider what nitrogen emissions reductions they could undertake, and not wait for this supposed Federal action to happen.

For instance, New York and Massachusetts took action on acid rain without waiting for Federal action, as just a preliminary step. We would encourage the bay states to start that kind of action on nitrogen emissions now.

Senator STEVENS. I would urge you to do that, because I think that until those states really show a commitment it is not going to be possible to do what you ask.

Thank you, Mr. Chairman.

Senator KERRY. Thank you, Senator Stevens.

OPENING STATEMENT BY SENATOR PRESSLER

Senator PRESSLER. Mr. Chairman, today's hearing focuses on an issue which has been the subject of dozens of hearings.

As a member of the Senate Environment and Public Works Committee and the Foreign Relations Committee I have chaired and been involved in many hearings on this issue. I have heard testimony on the impact of acid rain on lakes, streams, crops, human health, buildings and now coastal waters. Studies have been conducted on all of these issues. Often overlooked is the fact that sulfur dioxide emissions have been reduced and continue to decline. However, many people feel that further actions need to be taken to achieve greater reductions. The controversy on this issue relates to how we might achieve further reductions. Who should pay for emission control measures? How large a reduction do we need? Those are the questions that need to be addressed.

Mr. Chairman, I look forward to hearing the testimony and to working with the chairman on this issue.

No questions.

Senator KERRY. Well, I want to thank you. There are some additional questions and I would like to leave the record open if I can, so we can ask them. But I want to keep the other panels moving if possible.

I want to thank you both. And you might want to stay around. It may be that there may be some need at the end to ask you for some clarification on some comments on the study. So I would like to have you do that if you will.

Dr. OPPENHEIMER. We will do that. Thank you.

Dr. FISHER. Thank you.

[The following information was subsequently received for the record:]

SUPPLEMENTAL MATERIAL OF DR. DIANE C. FISHER

SENSITIVITY OF ATMOSPHERIC NITRATE LOADING ESTIMATE TO UNDERLYING ASSUMPTIONS

In the report, *Polluted Coastal Waters: the Role of Acid Rain* we estimate that atmospheric nitrate, a component of acid rain, contributes 25% of the total nitrogen loading to the Chesapeake Bay. This comes both from acid rain falling directly into the Bay, and from the contribution of acid rain to nitrogen in land runoff. In order to make this estimate, we made assumptions about how much nitrogen is retained by different land types. We also assumed that dry deposition of nitric acid vapors and gaseous oxides of nitrogen was approximately equal to wet deposition of nitrate, and that dry deposition of ammonia gases and ammonium species is approximately equal to wet deposition of ammonium.

Here we present the results of calculations in which we vary these underlying assumptions. We examine the effect this has on the calculated contribution of atmospheric nitrate deposition to total nitrogen loading of the Chesapeake Bay. We obtain a range of values of 21 to 32% for the contribution of atmospheric nitrate to nitrogen in the Bay. These results are presented in Table I. The calculation is most sensitive to the assumptions about dry deposition, and retention of nitrogen by forested ecosystems. It is least sensitive to the assumptions about retention of nitrogen by urban landscapes.

SENSITIVITY TESTS OF ATMOSPHERIC NITRATE LOADING CALCULATION TO THE CHESAPEAKE BAY

[Reported as percent of total nitrogen loading]

Parameter varied	Low	Medium	High
Forest retention	21	25	30
Urban retention	24	25	26
Pasture retention:			
Precipitation	23	25	
Animal waste	21	25	
Cropland runoff		25	27
Dry deposition	21	25	32

Below we describe how each of the sensitivity calculations in Table I was done. It is assumed that the reader is already familiar with the calculation of nitrogen loadings presented in *Polluted Coastal Waters: the Role of Acid Rain.* We therefore only discuss how the sensitivity calculations differ from this "base case".

FOREST RETENTION

For the base case, we assumed that 80 percent of the nitrogen input to forested ecosystems is retained by the forest, and that another 50 percent of the runoff is retained by the rivers, allowing only 10 percent of nitrogen input to forests to reach the Bay. The 80 percent value was based on literature values for retention of nitrogen by small forested watersheds, and was in the middle of the reported range of 52 to 97 percent. For the "low" case in Table I, we assume that forests retain 97 percent of nitrogen inputs, and that the runoff is reduced another 50 percent in the rivers, for a total runoff of only 1.5 percent. Both the atmospheric nitrate, and atmospheric ammonium inputs to forests were reduced by this amount. In this scenario, atmospheric nitrate loading becomes 21 percent of the total. For the "high" case, we assume a retention factor of 52 percent by the forests, and another 50 percent for the rivers, giving an overall retention of 76 percent. This causes atmospheric nitrate to rise to 30 percent of the total loading.

URBAN RETENTION

Urban areas are not expected to be very efficient in retaining nitrogen. All of the major urban areas in the Chesapeake Bay are located directly next to the Bay (including tidal portions of tributaries), so runoff from this land goes directly into the Bay. Urban areas are also covered by impervious surfaces which do not absorb nitrogen. We therefore estimated that urban lands would retain 0 percent (no retention) to 70 percent (same as croplands) of nitrogen inputs. For our base case, we assumed 35 percent retention.

For the "low" case, we assume 70 percent nitrogen retention by urban lands. Both atmospheric nitrate and atmospheric ammonium input to urban lands are reduced by this amount. This causes the atmospheric nitrate loading to fall to 24 percent of the total. For the "high" case, we assume 0 percent retention. This causes atmospheric nitrate to become 26 percent of the total. The calculation is relatively insensitive to the assumption made about urban retention because urban areas occupy only 3 percent of the total land area of the watershed.

PASTURE RETENTION

In our base case, we made separate assumptions about retention of atmospheric nitrogen and animal waste nitrogen by pastures. Based on a literature value for retention of animal waste nitrogen, we assumed that 95 percent would be retained. We reduced runoff of animal waste nitrogen by another 50 percent to account for river uptake, giving an overall retention of 97.5 percent. We assumed that the more soluble forms of nitrogen in atmospheric deposition would be retained about as efficiently by pastures as by croplands, or 70 percent retention overall, including river uptake.

In the "low" case for retention of atmospheric nitrogen by pastures, we assume that retention of this source is similar to that of forests, or 90 percent overall including river uptake. This lowers the atmospheric nitrate deposition contribution to 23 percent. We do not present a "high" case because we consider it unlikely that pastures would retain nitrogen less efficiently than croplands.

In the "low" case for animal waste retention, we assume 70 percent retention by the land, reduced by another 50 percent for river uptake, for 85 percent retention overall. This increases our estimated runoff of animal waste nitrogen by a factor of six. In this scenario, the relative contribution of atmospheric nitrate deposition is lowered to 21 percent of the total loading. We do not present a high case because it is unlikely that animal waste nitrogen will be retained more efficiently than in our base case.

CROPLAND RUNOFF

Our method for estimating cropland runoff for our base case was different than our method for calculating runoff from other land types. For other land types, we used retention factors to estimate the amount of each nitrogen input which would runoff. For croplands, we assumed that the EPA Chesapeake Bay Program's estimate for total cropland runoff was correct (This estimate is presented in the 1983 publication *Chesapeake Bay: A Framework for Action*), and then estimated the contribution of atmospheric nitrate deposition to this runoff.

The Chesapeake Bay Program reported that in a year of average rainfall 39.8 million kg of nitrogen would runoff croplands during the months of March through October (8 months). We assumed that nitrogen would runoff at the same rate during November through February as during the rest of the year, and multiplied EPA's 8 month total by 1.5 to approximate the annual runoff (59.8 million kg of nitrogen). We then compared total inputs of fertilizer and of atmospheric nitrogen to total runoff to derive a retention factor of 70 percent, including river uptake.

This method of approximating the annual runoff is almost certain to give an overestimate of cropland runoff. Virtually all of the fertilizer inputs to croplands are expected to occur during March through October. Runoff of nitrogen during the winter months should be less overall, and will arise primarily from atmospheric inputs, since other inputs do not occur in winter. Our base case estimate will overestimate the importance of fertilizer runoff, thus underestimating the percentage contributions from other sources.

For the "high" case presented in Table I, we assume that all fertilizer input occurs during March through October. We add this input to total atmospheric inputs during this 8 month period, and compare this input to total runoff to derive a retention factor of 78 percent, including river uptake. During winter months, we assume that the only inputs to croplands are atmospheric, and that these are retained with the same 78 percent efficiency. This actually lowers the estimated total loadings from atmospheric sources, but it lowers the estimated fertilizer contribution even more, so as a percentage the importance of all sources other than fertilizer rises. In this scenario, the contribution of atmospheric nitrate rises to 27 percent of the total nitrogen loading. We do not present a low case because it is unlikely that cropland runoff will be higher in winter than it is during the rest of the year.

DRY DEPOSITION

Atmospheric deposition of nitrate and of ammonium occurs in two forms: wet deposition of these ions in rainfall, and dry deposition of nitric acid vapors, gaseous oxides of nitrogen, and gaseous and particulate ammonium. Dry deposition is not routinely measured, but literature values show that it is approximately equal to wet deposition as a source of nitrogen. For our base case, we therefore assumed that dry deposition was equal to wet deposition.

For both our high and low cases, we assume the same total cropland runoff as in our base case. For this land type, we only change the relative contribution of atmospheric sources compared to fertilizer inputs. For other land types, we use the same retention factors as in the base case, thus changing the total calculated runoff from each land type. For our "low" case, we assume that dry deposition of both nitrates and of ammonium is only 50% of wet deposition. This causes atmoshperic nitrate to fall to 21% of the total loading. For our "high" case, we assume that dry deposition of nitrates and ammonium is twice wet deposition. Atmospheric nitrate then rises to 32% of the total.

ADDITIONAL TESTIMONY OF DR. DIANE C. FISHER

We would like to thank the Senate Committee on Commerce, Science, and Transportation, and the National Ocean Policy Study for the opportunity to submit additional written comments to supplement our testimony of the morning of June 8, 1988. In this additional testimony we will respond to the main points raised in the hearing about our recent report *Polluted Coastal Waters: the Role of Acid Rain* (hereinafter "the Report").

Some of the points raised during the hearing have already been addressed in a document which we submitted on the day of the hearing labelled "Supplemental Material" (hereinafter "the Supplement"). In this document, we presented "sensitivity" calculations, which test the effect varying our underlying assumptions has on our final conclusion. We have attached an additional copy of this document. We will discuss some of these calculations in more detail below, and will present some additional calculations and comments.

INTRODUCTION

None of the witnesses seemed to disagree with the basic proposition presented in the Report, that atmoshperic nitrate deposition, a component of acid rain, is an important contributor of the nutrient nitrogen to the Chesapeake Bay. Discussion focussed primarily on the degree of accuracy of our estimate of 25% as the contribution of acid rain to the total nitrogen loading to the Bay. Based on the sensitivity calculations presented in the Supplement and below, we conclude that the actual contribution lies somewhere in the range of 20 to 32%, with 25% as our best estimate. Based on EPA estimates, Dr. Linthurst suggested that the lower limit might be as low as 13%. As we explain below, we believe this is an underestimate. However, it is worth noting that even if we consider the range for the acid rain contribution to be 13 to 32%, this still represents a significant amount, especially given the 40 to 60% growth projected for this source in the next four decades.

The Chesapeake Bay program has established a goal of 40% reduction in nitrogen and phosphorus inputs to the bay. Even if the acid rain nitrogen contribution is only 13% of total manmade inputs, if the Bay states only control only those sources they are currently planning to control, and ignore atmospheric nitrate, they will only achieve a 28% reduction in nitrogen, and acid rain will grow to be more than one fourth the total input. If the acid rain contribution is 32%, only a 10% overall reduction in nitrogen inputs will be achieved, and the acid rain contribution will grow to be over 50% of the total.

It is important to note that most of the uncertainties about atmospheric nitrate as a source of nitrogen to the Bay are uncertainties which apply to all of the other sources. Uncertainties in escosystem retention factors, and seasonal and interannual variation in nitrogen loading apply to all nitrogen sources. Although it is worthwhile to conduct scientific investigations to reduce these uncertainties, cleaning up the Chesapeake Bay and other coastal waters cannot wait for the conclusions. In spite of the remaining uncertainties, the Bay states have committed to controlling point sources of nitrogen, and agricultural runoff. The same commitment should be made to control nitrogen oxide emissions, the source of atmospheric nitrate.

Professor Hans Paerl also presented tesmtimony which indicated that the nitrogen in acid rain may play an even more important role in promoting algal blooms offshore than it does within estuaries. This makes controlling nitrogen oxide emission even more important.

Below we discuss in detail some of the points raised about the Report.

ECOSYSTEM RETENTION FACTORS

Three witnesses, Dr. Linthurst of EPA, Dr. Jim Mahoney of NAPAP, and Dr. Charles Driscoll of Syracuse University, questioned some of the ecosystem nitrogen retention factors (the percent of nitrogen input to a given land type which does *not* wash off the land into streams or rivers) we used.

There are some constraints which limit the range of retention factors which it is reasonable to use. If we use values which are too high or too low, the amount of nitrogen which we calculate to wash off the land will fall well below or above the amount observed to enter the Bay via the rivers, even if we account for variations in wet vs. dry years. In all of our sensitivity calculations, we have tried to keep the total nitrogen loading which we calculate within the bounds of total nitrogen loadings which have been reported (Smullen et al. 1982, Gillelan et al. 1983, and Lang 1982).

The percentage of total nitrogen which we calculate for atmospheric nitrate is not as sensitive to ecosystem retention factors as one might at first expect. To understand this, it is instructive to look at Table I from the Report, included here as Figure 1. This reports non-point source (NPS) loading to the *watershed,* before the nitrogen in processed by the ecosystem.

Note that of the four sources contributing to NPS runoff, inputs of atmospheric nitrate to the land are nearly as large as either fertilizer or animal waste and almost twice as large as atmospheric ammonium.

In order to conclude that atmospheric nitrate is *not* an important source of NPS nitrogen, one would have to devise a system of ecosystem retention factors which would selectively retain this source, while allowing the other sources to pass through into streams. Atmospheric nitrate is highly soluble, and thus highly mobile. Chemically, it is identical to the nitrate which is one of the major nitrogen components of fertilizers. Unlike other NPS sources, a significant amount of atmospheric nitrate falls directly on the Bay and rivers, bypassing ecosystem retention entirely. Changing a retention factor for a given land type will change the predicted nitrogen runoff from *all* sources, not just atmospheric nitrate. For instance, if we raise our estimated cropland retention, this will reduce both runoff of atmospheric nitrate, and of fertilizer.

We have not been able to devise a scenario using any combination of reasonable retention factors which lowers the contribution of atmospheric nitrate below 20 percent.

RETENTION BY FORESTS

Based on literature values for nitrogen retention by forests, we chose a retention factor of 80 percent. Both Dr. Linthurst (EPA) and Dr. Mahoney (NAPAP) suggested that this might be too low. Dr. Driscoll seemed to be suggesting that 80 percent is actually too high, or at least that the range of 52 to 97 percent which we suggest in the Report is not broad enough.

In the Supplement, we show that using a 52 percent retention factor for forests gives a calculated acid rain contribution of 30 percent, whereas a 97 percent retention factor gives an acid rain contribution of 21 percent. Dr. Linthurst suggests that 93 to 99 percent might be appropriate, based on an as yet unpublished EPRI analysis. This analysis looked at forests "in the Chesapeake region". If these forests are confined to the coastal plains, this may explain the higher retention factor. Studies in coastal plain watersheds (e.g. Weller et al. 1986) seem to give Kelly et al. 1986, or Likens et al. 1977). The Chesapeake watershed includes both coastal plains and mountainous areas. However, even if we use a retention factor of 100 percent (excluding forest runoff entirely) the calculated acid rain contribution to the Bay is still 20 percent.

In Dr. Driscoll's testimony, he presented a Figure with data from the Hubbard Brook study (included here as Figure 2). The precipitation inputs shown in this Figure do not include gaseous inputs of nitrogen, whereas the reported retention factor (Likens et al. 1977) for Hubbard Brook does. Excluding these gaseous inputs will cause the calculated retention factor to be too low. This may explain why Dr. Driscoll believes only retention factor of 80 percent is too high. Even if one includes only the nitrogen inputs shown in Figure 2, the average retention factor over 23 years is 57 percent, well within the range that we've used. In fact, if one includes the gaseous inputs (which Likens et al. 1977 estimate to be roughly twice as large as precipitation inputs) it is likely that the retention factor for every single individual year of the Hubbard Brook study would fall within the range that we use.

Dr. Driscoll correctly notes that there is a lot of year to year variation. Obviously, a forest can't retain more than 100 percent, and if in any given year the average retention factor of forests is less than the 52 percent we have assumed as our lower limit, this will increase the contribution of atmospheric nitrate to greater than 30 percent of the nitrogen loading in that year. The reason we have not broadened the range of forest retention factors in our sensitivity analysis beyond 52 to 100 percent is that although there may be less retention in an individual forest in any given year, it is extremely unlikely that the overall *average* for all forests in the Bay's watershed would be less than this value. A lower retention also begins to give us calculated *total* nitrogen loadings which exceed those that have been observed.

Dr. Driscoll notes that there is a large amount of nitrogen stored in forests, and suggests that some of this may be released suddenly and inexplicably. Although this may be true, this is not something managers or legislators have control over. The EPA and the Bay states have recognized this and have set the goal of reducing *anthropogenic* sources of nitrogen by 40 percent.

Even the large uncertainties in nitrogen cycling by forests give us a range of 20 to 30 percent or greater for the atmospheric nitrate contribution to anthropogenic nitrogen loading to the Chesapeake Bay.

OTHER LAND TYPES

None of the witnesses raised specific questions about the nitrogen retention factors we used for land types other than forests. On pages 4 through 7 of the Supplement, we presented calculations in which these parameters are varied. We obtained a range of 21 to 27 percent for the atmospheric nitrate contribution to total nitrogen loading by varying retention of these land types.

DRY DEPOSITION

Several witnesses correctly noted that our calculations are sensitive to our assumption about the amount of dry deposition of gaseous nitric acid and oxides of nitrogen which occurs. Numerous studies (Kelly et al. 1986, Lovett, et al. 1986, Lindberg et al. 1986, Levy et al. 1987, Logan et al. 1983, and Derwent et al. 1986) indicate that dry deposition is one to four times as large as wet deposition of nitrate. Although the first three of the studies listed were conducted in forested areas where dry deposition tends to be high, regional scale nitrogen budgets (the last three studies listed) over large areas including many land types also indicate that dry deposition is equal to, or slightly higher than wet deposition. Preliminary data from NAPAP's dry deposition monitoring network (NAPAP 1987) indicates the same. Since the NAPAP data does not include deposition of No and No_2, and since these species often supply as much nitrogen as nitric acid vapors, the actual ratio of dry deposition to wet at this site may be much greater than one.

NAPAP suggests that by assuming dry deposition equal to wet, we may be overestimating deposition directly to the Bay. Although we acknowledge in the Report (p. 43) that this may be true, we believe this is more than compensated by the fact that we are likely to be underestimating deposition to forests, which occupy nearly two-thirds the land area of the watershed. The assumption we have made about dry deposition is a reasonable to conservative estimate.

Even though our estimate is more sensitie to our dry deposition assumption than to any other, we can vary this assumption substantially without changing our final conclusion. On pages 7 and 8 of the Supplement, we determine that lowering or raising our assumed dry deposition by a factor of two gives a range of 21 to 32 percent of the atmospheric nitrate contribution to nitrogen loading of the Bay. Thus even if our dry deposition estimate is off by a factor of two our basic conclusion, that atmospheric nitrate contributes a large amount of the total nitrogen in the Bay, is still valid.

SEASONAL AND INTERANNUAL VARIABILITY OF NITROGEN FLOWS

We base our calculations on the average annual total nitrogen loading to the Bay. Several witnesses correctly noted that there is a great deal of variation in nitrogen loadings from year to year, and from season to season. These variations will affect *all* sources of nitrogen.

Interannual Variations.—

Year to Year variations in nitrogen loading to the Bay depend primarily on the amount of rainfall in that year. In dry years there is less land runoff and less input of nitrogen from rivers, so direct nitrogen inputs to the Bay, such as sewage treatment plants become more important. In wet years, higher runoff causes all sources which contribute to runoff (e.g. fertilizer) to become more important.

Atmospheric nitrate is unique in that it is the only source which contributes both to land runoff and to direct inuts of nitrogen into the Bay. We estimate that it contributes 21 percent of direct inputs, and 27 percent of inputs from runoff. Thus, one expects there to be *less* year to year variation in the percent contribution of this source than of any other.

Since we cannot control whether any given year wil be wet or dry, it makes sense to base management strategies on an average year. Apparently the EPA Chesapeake Bay Program (EPA-CBP) recognizes this, since the study on which they base their call for 40 percent reductions of nitrogen and phosphorus inputs is based on an average year (Hydroqual 1987).

Seasonal Variation.—There are also seasonal variations in nitrogen loadings. Two of the three major EPA-CBP studies on nitrogen loading to the Bay did not examine seasonal variation of nitrogen inputs (Gillelan et al. 1983, Hydroqual 1987). The 1983 study was based on average loadings for March through October. The 1987 study examined July-August only. The one EPA-CBP study which did look at seasonal inputs (Smullen et al. 1982) showed that atmospheric inputs of nitrogen directly into the Bay are highest during the critical summer season when nuisance blooms of algae and oxygen depletion are most severe. As noted in NAPAP's testimony (p. 6), wet deposition of nitrate to land is also higher in summer. Dry deposition to many surfaces is also higher in summer (Voldner et al. 1986). This will increase the relative contribution of atmospheric nitrate to land runoff compared to other sources. For these reasons, we suspect that nitrogen loading from atmospheric nitrate may be an even greater than 25 percent of the total in this critical season.

As we discuss in the Report (p. 32 to 33), there are good reasons to control nitrogen year around. Even inputs in the relatively dormant winter season may linger long enough to influence summertime blooms.

EPA ESTIMATES OF THE ACID RAIN CONTRIBUTION TO NITROGEN LOADING OF THE CHESAPEAKE BAY

Both Dr. Linthurst and Dr. Mahoney claimed that the EPA Chesapeake Bay Program has in fact been including atmospheric inputs in its nitrogen budgets for the Chesapeake Bay. This is only partially true. Two of the three major EPA-CBP studies (Smullen et al. 1982, Hydroqual Inc. 1987) include only atmospheric nitrogen deposited by bulk precipitation directly to the Bay. Of the three routes by which atmospheric nitrate reaches the Bay, this includes only one (wet precipitation), and a small fraction of another (dry deposition: bulk precipitation collectors do not efficiently collect nitrogen gases). The third and most important route, land runoff of atmospheric nitrate, is included as a river input, but is not identified as coming from atmospheric nitrate, and so is not included in the calculated percentage for this source. In the third of the three EPA-CBP nitrogen budgets (Gillelan et al. 1983) atmospheric inputs were completely ignored.

Thus EPA-CBP estimates to date have ignored or seriously understimated the contribution of atmospheric nitrate to nitrogen loading of the Bay. This would almost certainly include the 13 percent figure cited by Dr. Linthurst as a previous EPA estimate of atmospheric nitrate loading to the Bay. We therefore do not consider 13 percent as a valid lower limit.

PROJECTIONS OF FUTURE EMISSIONS OF OXIDES OF NITROGEN

NAPAP notes that our projections on the future role of acid rain nitrogen in the Bay are based on projections of future NOx emissions. We used projections reported in the NAPAP Interim Assessment (NAPAP 1987), which NAPAP notes have large uncertainties due to the long projection period.

All three of the projections reported on page 3-29, Volume II of the Interim Assessment (Figure 3) are based on very optimistic energy use scenarios. The NAPAP "base case" asumes that the use of nuclear energy will triple in the next forty years, and that old power plants will be retired at fifty years of age. In fact, no new nuclear plant has been ordered for more than ten years, and power plants built in the 1950's through 1970's were clearly designed to last longer than sixty years.

We chose to work with the ANL projection because it was the most conservative of the three, and because the two EPA projections are based on a draft EPA report which the EPA would not release to us. The ANL projection predicts a 44 percent increase in NOx emissions in the regions which will most affect nitrate deposition in the Chesapeake Bay watershed (EPA regions III, IV, and V). The two EPA scenarios predict a 48 percent to 55 percent increase. Given the optimistic assumptions all of these projections are based on, we believe that as much as a 60 to 75 percent increase may be more likely.

NAPAP also cities projections of smaller NOx increases (e.g. Figure 4) based on more widespread use of better technologies. We believe that these projections are very unrealistic. However, it is worthwhile to note that even if the lowest projection in figure 4 somehow came to pass, *total Nox emissions would still increase substantially.* Figure 4 is for utility emissions only, and the lowest projection represents a 4 million ton reduction from this sector by 2030. If we couple this decrease with the most conservative projection in Figure 3 (ANL), this would change 2030 NOx emissions from 25.2 to 21.2, still representing a 25 percent increase from the 1980 value of 16.9.

To test the effect of different emission projections on our prediction for the future of the Bay, we take 25 to 75 percent as the range of likely increases. We calculate the future loadings in the same manner as described in the Report (pp 65–68), with these high and low case projections. If the other sources of nitrogen to the Bay are controlled and NOx emissions are ignored, acid rain grows to be the largest source in either the high or low scenario, representing 40 to 48 percent of the total nitrogen. Rather than achieving the desired 40 percent reduction in total nitrogen loading, only a 9 to 21 percent reduction will be achieved.

CORRELATION OF PREVIOUS NITROGEN LOADING TRENDS TO EMISSIONS

NAPAP's testimony (p. 3) points out that a 30 percent increase in nitrate drainage to the Chesapeake Bay from 1974 to 1981 (from Smith et al. 1987) occured during a period when NOx emissions remained relatively constant (based on Knudson et al. 1986).

Some emissions inventories (e.g. Gschwandter et al. 1985) do show modest increases during the period 1974 to 1981. However, even if NOx emissions remained constant during this period, the move to taller smokestacks which occured during the same period could still cause nitrate concentrations in rainfall to increase. Figure 5 presents data of Correll et al. from the Chesapeake Bay Center for Environmental Studies of the Smithsonian Institution (Correll et al. 1982). Rainfall nitrate concentration increased steadily from 1974 to 1980 in the Rhode River estuary, a sub-estuary of the Chesapeake Bay. If the observed increase at this site is typical of the region, it could easily explain a 30 percent increase in riverine nitrate loading.

Furthermore, even if the atmospheric nitrate fraction of nitrogen loading remained constant during this period, and the *increase* was attributable to other sources, this wouldn't preclude atmospheric nitrate from being a large, albeit constant, source.

SINGLE NUTRIENT CONTROL STRATEGY

EPA's testimony suggests that we are endorsing a strategy to control only nitrogen, ignoring phosphorus, which is also thought to be contributing to the problems in the Chesapeake Bay. We focussed on nitrogen because we were interested in determining the role of acid rain in these problems. Acid rain does not contribute phosphorus to the Bay. However, our focus on nitrogen should not be interpreted as lack of support for phosphorus controls. The EPA CBP has established goals of 40 percent reductions in both phosphorus and nitrogen. We support these goals for *all* sources of both nutrients, including acid rain.

ATMOSPHERIC NITRATE AS FERTILIZER SUBSIDY

NAPAP suggested that if nitrogen inputs to farmland from acid rain were to decrease, that farmers would have to apply more fertilizer to make up for the lost nitrogen, or suffer lost crop productivity. This assumes that farmers are already applying exactly the right quantity of nitrogen, when in fact there is a tendency to overapply fertilizers. Farmers can also apply fiertilizers at the exact time of year it is needed, which is not true of acid rain. Acid rain falls in the dead of winter, and on fallow as well as planted fields. For these reasons, it is simply not true that decreaed acid rain will necessitate increased use of fertilizer.

CONCLUSION

There are certainly remaining uncertainties about nitrogen cycling in watersheds as large as the one surrounding the Chesapeake Bay. These uncertainties apply to all sources of nitrogen, especially non-point sources such as fertilizers and animal waste, as well as atmospheric nitrate. Although diminishing these uncertainties is a worthwhile scientific endeavor, cleaning up the Chesapeake and other nutrient stressed estuaries cannot wait for these studies to be concluded. We know that there is too much nitrogen in our coastal waters, and we know enough about the sources of nitrogen to begin the job of cleaning up.

None of the remaining uncertainties invalidate our conclusion that atmospheric nitrate is responsible for a large fraction of nitrogen loading to the Chesapeake. It is also likely to be contributing large amounts of nitrogen to other nutrient stressed Eastern coastal waters. Even given the uncerrtainties in future nitrogen oxide emissions, there is no doubt that without further legislation this source of nitrogen to our coastal waters will continue to grow. Enacting legislation to reduce these emissions will help the Chesapeake Bay and other troubled coastal waters on the long road to recovery.

[Figure 1. From *Polluted Coastal Waters: the Role of Acid Rain*]

TABLE I.—CALCULATED NITROGEN LOADINGS TO CHESAPEAKE BAY WATERSHED, 1984

Source	10 kg/ year	kg/ha-yr	Percent of total	Percent of NPS
Precipitation:				
Nitrate	143	8.7	23	25
Ammonium	79	4.8	134	14
Animal waste	195	11.9	32	34
Fertilizer	158	9.6	25	27
NPS subtotal	575	35.1		100
Point sources	41	2.5	7	
Total	616	37.6	100	

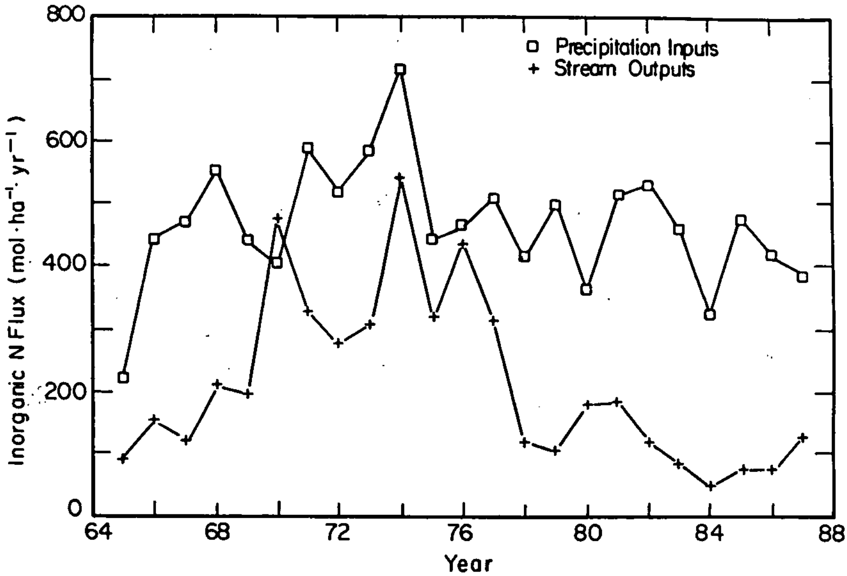

Figure 2. From testimony of Charles Driscoll, June 8, 1988

Precipitation loading and stream outflow of inorganic nitrogen ($NH_4^+ + NO_3^-$) at the Hubbard Brook Experimental Forest, NH

FIGURE 3

From the Interim Assessment - Pages 3-28 and 3-29

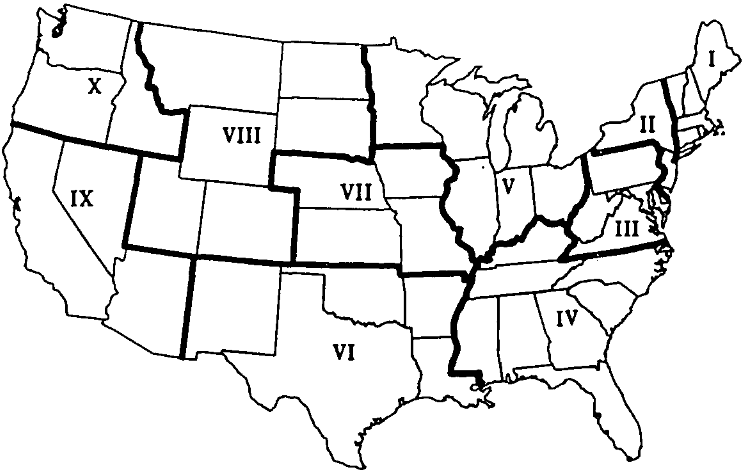

Figure 3-17.–Federal regions of the United States.

Table 3-5.—Long-term changes in regional NO_x emission patterns.

	ANL/NEPP			EHP/EPA/A			EHP/EPA/B		
	EMISSIONS		% CHANGE 1980–2030	EMISSIONS		% CHANGE 1980–2030	EMISSIONS		% CHANGE 1980–2030
FEDERAL REGION	1980	2030		1980	2030		1980	2030	
I New England	0.52	0.71	37	0.80	1.29	62	0.80	1.28	61
II New York/New Jersey	0.95	1.50	58	1.21	1.61	33	1.21	1.57	30
III Middle Atlantic	1.90	2.62	38	2.10	2.74	31	2.10	2.96	41
IV Southeast	3.26	5.33	63	3.68	6.17	67	3.68	6.25	70
V Great Lakes	3.91	5.07	33	4.09	5.66	38	4.09	6.05	48
VI South Central	2.70	4.74	76	3.99	6.61	66	3.99	6.62	66
VII Central	1.17	1.41	21	1.22	1.51	25	1.22	1.59	31
VIII Mountain	0.75	1.14	52	0.92	2.21	142	0.92	2.28	149
IX West	1.35	1.91	41	1.70	2.38	40	1.70	2.40	42
X Northwest	0.44	0.79	80	0.57	1.71	202	0.57	1.67	194
Total	16.9	25.2	49	20.2	31.9	58	20.2	32.7	61

Emissions expressed in 10^6 metric tons/yr.

Sources: E.H. Pechan & Associates, Inc. 1986; Placet et al. 1986.

Figure 4. From the NAPAP Interim Assessment, p 3-23, Volume II

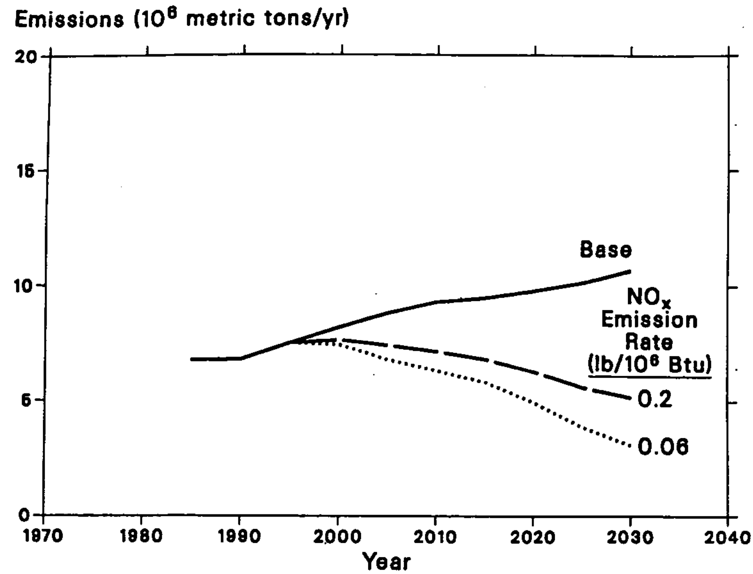

Figure 3-12.–Sensitivity of utility NO_x emission projections to environmental performance of new technology after 1995. The base case assumes 0.6 lb/10^6 Btu.

Figure 5. From Correll et al. (1982)

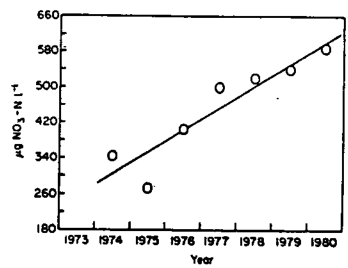

Figure 3. Changes in nitrate–nitrogen concentration in summer bulk precipitation over a 7-year period at Rhode River. Each point is the arithmetic mean of data from all precipitation events for the season. $R = 0{\cdot}93$.

Senator KERRY. If we could have the members of the second panel, please, Mr. Jim Mahoney and Mr. Rick Linthurst, please.

Mr. Mahoney is Director of the National Acid Precipitation Assessment Program, and Mr. Linthurst is the Acting Deputy Director of the Office of Acid Deposition for the Environmental Monitoring and Quality Assurance Division of the Environmental Protection Agency.

Mr. Linthurst, do you want to lead off.

STATEMENT OF RICK A. LINTHURST, ACTING DEPUTY DIRECTOR, OFFICE OF ACID DEPOSITION, ENVIRONMENTAL MONITORING AND QUALITY ASSURANCE, ENVIRONMENTAL PROTECTION AGENCY

Mr. LINTHURST. Good morning. I am Rick Linthurst, as you indicated, Acting Deputy Director of the Office of Acid Deposition, Environmental Monitoring and Quality Assurance in the U.S. Environmental Protection Agency.

I would like to note that over the past few months several representatives of the EPA have testified before relevant House and Senate committees on the importance of our near coastal waters and our activities to protect this valuable resource.

In that regard, I am pleased to have this opportunity to appear today before the committee on behalf of EPA to discuss the Environmental Defense Fund report entitled "Polluted coastal waters: the role of acid rain." My written testimony has been submitted to the committee for the record and I would like to summarize briefly the key points of that testimony.

We believe that the authors have taken a reasonable approach, based on available data, to apportioning the sources of nitrogen inputs to the Chesapeake Bay. We also concur with the report in that atmospheric nitrogen deposition cannot be ignored in an evaluation of either total nitrogen loadings to estuaries or the collective effects of pollutants on our estuarine resources.

However, we believe, and some discussion has already been held here concerning this point, that the report's recommendation to reduce atmospheric inputs of nitrate by 40 percent based on the data presented is premature because of two primary limitations:

One, the uncertainty of the assumptions, and therefore the estimated nitrogen loadings; and the premise that nitrogen is the most important factor affecting the water quality in the bay.

While the approach taken by the report's authors is reasonable based upon our understanding of currently available data, the accuracy of the results cannot be determined. That is, it is really not possible to say with a high degree of certainty if the source apportionments are correct, too high, or too low.

As acknowledged by the authors, many of the assumptions that had to be made to complete the report could not be accompanied by quantitative uncertainty estimates simply because they were not available.

An example of one of the uncertainties is the nitrogen retention factor used in forested ecosystems. This factor represents the percentage of nitrate retained in the terrestrial component of the watershed and therefore determines how much of the nitrate coming into that watershed actually reaches the streams and rivers flowing into the bay.

The retention factor used was 80 percent. This may be low, based on information from the watershed area. If a higher retention factor was used, atmospheric nitrate contribution would be reduced by maybe four or five percent. So that would bring the number down to somewhere around 20 percent.

While this is a small change relative to an assessment of this type, uncertainties in the accuracy of dry deposition, wet deposition, cropland, pastureland, runoff assumptions would also have effects on that source apportionment in the range of a few percent.

And collectively, the uncertainty then can be quite large. This calls into question the magnitude of the atmospheric nitrate contribution, but does not alter the belief that atmospheric deposition of nitrate contributes to the total loading of nitrogen in the bay and that it should not be ignored as one of those sources.

Another limitation of the report is the authors' premise that the nitrogen is the controlling factor in water quality in the bay. We believe a single-nutrient approach to improving water quality is an oversimplification of the problem.

Both phosphorus and nitrogen can be limiting, depending on the time of the year or the portion of the bay under study, as suggested in the report itself. Consistent with that understanding of nutrient loadings, action has really been taken relating to both nutrients.

The 1987 Chesapeake Bay agreement among Maryland, Virginia, Pennsylvania, and the District of Columbia agreed to reduce the nutrient loads of both phosphorus and nitrogen by 40 percent by the year 2000. Whatever additional nitrogen reductions are warranted might best be achieved by studies to quantify optimal loadings for carefully defined goals in that system.

The research and monitoring now under way in the bay will reduce the uncertainties associated with the assumptions that went into this current report. Refinements expected from these continuing studies should permit increasingly accurate source apportionments in the future and can be used to assess the adequacy of the current management strategy being implemented in that area.

I would like to thank you again for this opportunity to discuss this important environmental issue, and I would be pleased to answer any questions you may have at this time.

[The statement follows:]

STATEMENT OF RICK A. LINHURST, PH.D., OFFICE OF RESEARCH AND DEVELOPMENT, U.S. ENVIRONMENTAL PROTECTION AGENCY

Good morning, I am Rick Linthurst, acting Deputy Director of the Office of Acid Deposition, Environmental Monitoring, and Quality Assurance in the U.S. Environmental Protection Agency. Over the past few months, several repesentatives of EPA have testified before relevant House and Senate Committees on the importance of our estuarine and near-coastal waters, and our activities to protect this resource. Without repeating the substance of the Agency's previous testimony, I would like to express our continuing concern over the condition of this important resource. In that regard, I am pleased to have this opportunity to appear today before the Committe on behalf of EPA to discuss the Environmental Defense Fund report entitled "Polluted Coastal Waters: The Role of Acid Rain."

I would like to provide my testimony in three parts. I will first discuss in general terms the strengths of the EDF report, followed by our perception of its primary limitations and, finally, I would like to comment on the adequacy of current monitoring in the near-coastal environment.

The EDF report correctly notes that human activities are affecting a broad geographical area, and are now affecting global biogeochemical cycles. Specific to estuarine ecosystems, reports of toxic tides, fish kills, eutrophication, loss and alteration of coastal wetland habitat and contamination by toxics and pathogens indicate that the productivity and environmental quality of the near-coastal environment is at risk.

The EDF report attempts to evaluate one of many stress factors that need to be considered in the protection of estuarine resources. We believe the authors have taken a reasonable approach to apportioning the sources of nitrogen inputs to the Chesapeake Bay. We also concur with the report in that atmospheric nitrogen deposition cannot be ignored in an evaluation of either total nitrogen loading to estuaries, or the collective effects of pollutants in our estuarine rsources. However, we believe that the Report's recommendations are premature because of two limitations: the uncertainty of the assumptions and therefore the estimated nitrogen loadings, and the premise that nitrogen is the most important factor affecting water quality in the Bay. I would now like to discuss each of these limitations briefly.

In any assessment one must make assumptions in the absence of a complete data base. Each assumption has an associated uncertainty that is used in evaluation the confidence on can have in the results. While the approach taken by the Report's authors is reasonable based on our understanding of currently available data, the accuracy of the results cannot be determined. While many of the assumptions might be challenged, the authors selection of an 80% nitrogen retention factor used for forested ecosystems is one example of a key scientific uncertainty.

Atmospheric deposition of nitrate to the watershed of the Chespeake Bay occurs largely as inputs to the forested ecosystem, reported to represent 62 percent of the watershed. The inputs of nitrogen species in atmospheric deposition to the watershed are significant as stated in the Report. The fraction of that loading to the terrestrial ecosystem expected to reach the surface water and the Bay, however, could well be much less than that estimated in the Report. While the authors clearly considered the problems with their estimate and provided a rationale for the selection of the retention factor used, their assumption is inconsistent with our understanding of recent findings of the Electric Power Research Institute's RILWAS project. In a report that is currently in preparation, the EPRI study concludes for watersheds in the Chesapeake Bay region that 1 to 7 percent of the nitrate input is exported from the terrestrial ecosystem. If additional nitrate is used in the river system, only a small fraction of the input may actually reach the Bay. These high retention rates are consistent with loading assessments made internationally in recent years. If in fact the retention rates are closer to 93 to 99 percent rather than 80 percent, the contribution from forested lands in the watershed, and therefore the amount of atmospheric nitrate ultimately reaching the Bay, would be substantially less than indicated in the EDF Report.

A larger retention factor of 93–99 percent would decrease the forest contribution of nitrate, lowering the 25 percent source percentage of atmospheric nitrate estimated in the Report by 4 or 5 percent. Uncertainties in the accuracy of dry deposition, cropland run-off, and other assumptions could also have varying effects on the source apportionment. However, while all of these uncertainties call into question the accuracy of the estimates, I would like to repeat that they will not likely affect the previously held belief that deposition of nitrate from the atmosphere is a contributing factor. It does suggest that our understanding of short- and long-term nitrate retention in terrestrial ecosystems could be further refined, thereby improving the assessment.

Concerning the premise that nitrogen is the limiting or controlling nutrient, a single nutrient reduction strategy for improving water quality in the Bay may be an oversimplification of the issue. Both phosphorus and nitrogen can be limiting depending on the time of year or the portion of the Bay under study. Consistent with our understanding of the nutrient loadings, action has been taken relating to both nutrients.

As noted in the testimony of the Deputy Administrator of EPA, A. James Barnes, before the Senate Subcommittee on Environmental Protection on April 20, 1988, an agreement among Maryland, Virginia, Pennsylvania, and the District of Columbia has been established to govern the activities affecting the Chesapeake Bay. The 1987 agreement identified priority goals to protect the Bay and negotiated commitments and schedules for achieving those goals, which include:

By the year 2000, reducing by 40 percent the nutrients discharged to the Bay—a commitment requiring major investments in facility construction and sophisticated

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treatment and/or implementation of highly effective non-point source control programs.

The recognition that development and uncontrolled population increase in coastal areas is one of the major causes of coastal degradation. Where adverse effects result from over-development, the agreement calls for the adoption of policies designed to anticipate and reduce them.

Development of a unified, Bay-wide public information, communication, and participation plan to encourage a greater sense of public "ownership" of the Bay and respect for its ecological limits.

The uncertainty in our understanding of processes or source apportionments that I have mentioned will be reduced as the Chesapeake Bay Program continues. The Program is now in a most important phase of any research and monitoring program, establishing baseline conditions. Because one of the objectives of the Bay Program is to quantify trends, it will be these data that will ultimately allow us to verify the relationships among atmospheric nitrate deposition, water quality, and biological effects. Refinements expected from this continuing study should permit increasingly accurate source apportionments in the future.

Thank you once again for this opportunity to discuss an important environmental issue. I would be pleased to answer any questions you may have at this time.

Senator KERRY. Thank you very much.

Mr. Mahoney.

STATEMENT OF JAMES R. MAHONEY, DIRECTOR, NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM

Mr. MAHONEY. Thank you, Mr. Chairman.

I appear as Director of NAPAP, as you indicated at the opening. I would also say I appear as a 25-year resident of Massachusetts before arriving here in Washington and as a product of its universities, and I am pleased to be present here today.

In summary, in my statement I want to indicate the role of NAPAP and then our view of the report which is the subject of this hearing.

The National Acid Precipitation Assessment Program was established by the Congress in the Acid Precipitation Act of 1980 and charged with conducting an intensive ten-year program of research in scientific, technological, and economic assessment on acid deposition causes, effects, and control measures to support the development of national policy and plans relative to acid rain control.

Within the next three months, NAPAP will issue for public review and comment a detailed plan for its completion of the 1990 integrated assessment and will make that available for review by the Congress and by all interested parties by the end of the summer.

The fundamental technical hypothesis in the EDF report is that atmospheric deposition of nitrogen is a significant factor in the total nitrogen budgets of coastal waters in the eastern United States and, I might say, in other regions as well.

Similar hypotheses have been reported by others, some of which are also cited in the EDF report and further cited in the testimony previous to this panel. This fundamental hypothesis has merit and it does deserve continuing evaluation, in particular because of the potential for future increases in nitrogen emissions during the years ahead.

The estimate prepared by EDF, that is that approximately 25 percent of all mand-made nitrogen arriving in the Chesapeake Bay results from the acid deposition route, is based on a chain of calculations which involve significant uncertainty at several key points.

These uncertainties involve everything from the underlying emissions estimates to the deposition rate assumptions, the key estimates on the rate of retention of nitrogen in the ecosystems, the forests and the croplands and the open pasturelands, and ultimately the fate of nitrogen in the aquatic systems and streams that would bring it to the bay.

Further analysis of these assumptions and independent scientific review of these concepts are appropriate to address the uncertainties which have been introduced. Decisions on effective controls for eutrophication in coastal waters in the Chesapeake Bay and others can best be made when a few key steps are taken in order.

First, it is necessary that goals for long term loading of nutrients in the waters be established, and that is of course goals for reduction in those loadings to provide adequate protection.

Second, as to the atmospheric route which is being discussed here today, resolution of these key uncertainties—that is, on the matter of whether 25 percent is a reasonable estimate—need to be addressed.

And third, any recommendations of control strategies must review the effectiveness and practicality of a whole series of measures, including those for non-point source control, fertilizer runoff, and other agricultural and husbandry practice controls, as well as the effectiveness and cost efficiency of various atmospheric controls.

So our general view is that the hypothesis that atmospheric deposition is a significant factor is the same as that you have heard. We call attention to the uncertainties which have been expressed. We believe that the report merits far more detailed and independent review than we have heard so far here today, and I believe it will get that.

And we note that any call for a specific type of control all the way at the upstream end, that is relative to specific air emissions, must view the whole chain getting to the final question in this matter, which is that of the eutrophication of the bay.

Before concluding my statement, I wanted to call attention by a couple of quick examples to the problem of uncertainty we see in the analysis. And understand, my comments about uncertainty are not meant to undermine the analysis, but to point out the importance that I think the previous panel would share in view of the importance of a continued careful view of all of the system analysis of the nitrogen deposition and its role in the bays.

First, I would note that the EDF report makes a reference—and to be specific, I will note it is on page 10—makes a reference to a 30 percent increase in nitrogen loading in streams entering the bay during the period 1974 to 1981. This is referenced in my prepared statement, and figure 1 in my prepared statement is a plot of nitrogen emissions for the nation as reported in the NAPAP interim assessment, which was published last year.

By quick evaluation, it is easy to see that the nitrogen emission profile in the nation, and I might say similarly in these regions in the East, which are available in other graphs in the same report, that that profile is basically flat through those years, all through the mid-seventies and in fact on up through the mid-eighties.

The reason for that is the effectiveness of the first round and second round of the Clean Air Act controls counterbalancing the increased economic activity during that period.

So we have a notice of 30 percent increase in nitrogen drainage into the bay during this period as reported by EDF standing against a record of flat, unchanged nitrogen emissions during that period.

Again, I cite this not to try to challenge or undermine the analysis, which as I said at the beginning we fundamentally concur with the hypothesis that atmospheric deposition is important and needs to be examined. But I cite this only to show the need for a careful evaluation and segregation so that we do not blame the wrong source for certain parts of our analysis.

Senator KERRY. But there is a simple answer for that, is there not? I mean, this is cumulative. It has always been cumulative. It is just like the relationship of alkilinity and pH. You have a curve, and as the alkilinity gets reduced your dropoff in your level of ability to survive is that much increased. So you go into total acidification at a rapid rate.

It is the same thing with nitrogen. You could have a steady of emission, but it is cumulative in its effect. And as the algae grows and begins to take over, coupled with the other problems that are there, you have an increasing problem.

I mean, as Senator Stevens said, for 17 years he has been sitting here and listening to this. I have had much less time, but it seems to me that we are avoiding that cumulative effect in that response.

Mr. MAHONEY. Mr. Chairman, the cite is to the streamflow levels of nitrogen entering the bay, not to the cumulative effect. And the cumulative effect argument or analysis is appropriate for a standing body of water, such as a lake. It is appropriate for the bay taken as a whole.

But the measurements I referred to are in-stream measurements, that is the rate of flux into the bay. And that has a very short time scale, on the order of a week or a month from precipitation to at least initial runoff.

So the point is when we see a major increase in this rate of flux as opposed to that in standing water, we have to say that something was changing during that period. And my guess would be that the fertilizer runoff and other non-point source contributions massively increased during that period. That is the sense of the comment.

I was raising this only as a caution, remembering that we do not dispute the fundamental hypothesis. But when we look at the actual data as to what is entering the bay, we have to be careful not to jump to a too easy conclusion about this apportionment. And that is the sense of my comment.

And I think with that I would conclude my prepared statement.

[The statement follows:]

STATEMENT OF JAMES R. MAHONEY
DIRECTOR OF THE NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM
BEFORE THE COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION
UNITED STATES SENATE

JUNE 8, 1988

Thank you for your invitation to appear before the committee today, to discuss the effects of atmospheric nitrogen deposition on coastal waters, with special emphasis on the report "Polluted Coastal Waters: The Role of Acid Rain" released by the Environmental Defense Fund (EDF) in April, 1988.

The following comments summarize the principal aspects of this statement:

o The National Acid Precipitation Assessment Program (NAPAP) was established by the Acid Precipitation Act of 1980, and charged with conducting an intensive 10-year program of research and scientific/technological/economic assessment on acidic deposition causes, effects and control measures, to support development of national policy on acid rain. NAPAP will issue its Integrated Assessment in 1990. More than two thousand scientific publications have resulted from NAPAP research, and several of these publications were utilized as sources of information in the EDF report.

o The fundamental technical hypothesis in the EDF report is that atmospheric deposition of nitrogen is a significant factor in the total nitrogen budgets of coastal waters in the eastern United States. A similar hypothesis has also been postulated by EPA researchers and other investigators in previous studies, some of which are cited in the EDF report. The fundamental hypothesis has merit, and deserves continuing evaluation, particularly given the potential for future increases in nitrogen emissions.

o The EDF estimate that approximately 25 percent of all anthropogenic nitrogen reaching the Chesapeake Bay results from atmospheric deposition is based on a chain of calculations involving significant uncertainty at several key points. These uncertainties involve emission estimates, deposition rate assumptions, estimates of retention of nitrates in the receiving terrestrial ecosystems, effects of geographic and seasonal variability, and the complex mechanics of nutrient cycling in coastal water systems. Further analyses and independent scientific reviews are needed to reduce the several uncertainties.

o Decisions on effective controls for eutrophication in coastal waters, including possible reductions of nitrogen oxide emissions, can best be made when the following actions have been taken: (1) Establishment of goals for long-term loadings of nutrients (both phosphorus and nitrogen) to control eutrophication in the affected coastal waters, (2) resolution of the significant uncertainties in the estimated contribution from atmospheric nitrate to total nitrogen loads, and (3) evaluation of the practicality and cost effectiveness of various control approaches, involving a mix of fertilizer and animal waste controls, improved sewage treatment, and atmospheric emission reductions.

o NAPAP has extensive field data and scientific analyses which relate to the question of atmospheric nitrogen deposition. Much of this information has already been published for use by the scientific and regulatory communities. NAPAP is prepared to assist other federal, state and local government programs, and to provide relevant technical information to other investigators, to aid in the further evaluation of atmospheric nitrogen deposition as a stress on coastal waters. Also, NAPAP will evaluate the available technical information on atmospheric nitrogen deposition as a factor in eutrophication in coastal waters, for incorporation in its 1990 Integrated Assessment.

The remainder of this statement is divided into four parts containing more detailed information which may be useful to the Committee. These are: (1) a review of NAPAP's responsibilities and specific plans to complete its 1990 Integrated Assessment on acidic deposition causes, effects and control measures, (2) a summary of NAPAP data and analyses relevant to atmospheric nitrogen deposition effects in coastal waters, (3) comments on uncertainties in the EDF analysis, and (4) other issues which may be relevant for policy evaluation of atmospheric nitrogen deposition as a factor in eutrophication in coastal waters.

NAPAP'S RESPONSIBILITIES AND REPORTING PLANS

NAPAP has a statutory responsibility to develop comprehensive scientific, technological and economic information related to acidic deposition. Its scope includes: (1) the sources of the atmospheric emissions which contribute to acidic deposition, (2) the atmospheric processes by which the acidic species are formed, transported and deposited, (3) the geographical areas of impact, including the definition of sensitive areas, (4) the dose-response mechanisms which describe effects of acidic deposition, (5) the extent and severity of the effects attributed to acidic deposition, (6) the time sensitivity of the forecasted effects, considering emission levels expected to occur over the years and decades ahead, (7) the costs, applicability and effectiveness of a range of available control measures, and (8) benefit valuation methods (both monetary and non-monetary) for differential analysis of various control measures.

NAPAP has recently announced, and begun to implement, plans to assure that these responsibilities are met in the major findings and recommendations it will report during the next two years. These plans include:

o Preparation of a detailed written plan for the 1990 Integrated Assessment, to be released for public comment during the summer of 1988. An open review meeting will be convened to receive comments, and a revised version of the plan will be completed before the end of 1988. The assessment plan will: (1) specifically define the various acidic deposition effects under consideration, (2) indicate the methods to define severity and geographic extent of effects, and (3) pose specific questions about the relative efficiency and effectiveness of alternative control measures.

o Completion of comprehensive state-of-science and state-of-technology reviews covering the several aspects of the acidic deposition issue. These reviews will survey both NAPAP and non-NAPAP developed information, will have extensive peer review, and will be critically discussed in an international technical meeting to be held in the United States in late 1989.

o Completion of the 1990 Integrated Assessment answering the questions posed in the assessment plan to be published later this year. The Integrated Assessment will provide structured information on the severity, geographic extent and time sensitivity of acidic deposition effects, and on the characteristics of a range of generic control measures. The information developed to assess control alternatives will be made available to federal agencies and other interested organizations so that comparative analyses of detailed proposals can be carried out.

o Appointment of an independent scientific oversight committee, to serve throughout the final two years of NAPAP activities. This committee will provide oversight on NAPAP's principal analyses and reports, and on NAPAP's continuing peer reviews which deal with specific technical issues.

NAPAP DATA AND ANALYSES ON ATMOSPHERIC NITROGEN DEPOSITION

The issue raised by the EDF report involves the nutrient property of nitrogen and is distinct from the mechanisms of acidification of surface waters. The issue of eutrophication research of coastal water is the primary responsibility of other programs such as EPA's National Estuary Program, the Sea Grant program of NOAA, and the federal-state Chesapeake Bay Program. NAPAP has not conducted research or assessment related to the role of nitrogen deposition in enhancing eutrophication processes, but has developed extensive data and analyses on nitrogen deposition processes which can support the EPA and NOAA programs, as well as state- and local-sponsored programs.

The following comments provide examples of some of the kinds of information developed by NAPAP relevant to this issue.

Nitrogen Emissions

The temporal and spatial patterns of anthropogenic emissions of oxides nitrogen (NOx) are discussed in NAPAP's 1987 Interim Assessment. Within the mid-Atlantic region, highway vehicles accounted for 39 percent of anthropogenic NO_x emissions and power plants accounted for 34 percent. This is similar to the national pattern of NO_x sources cited in the EDF report. Since 1975, the national and regional emissions of NO_x have been approximately constant year-to-year and season-to-season (see Figure 1). In comparison to the constant levels of NO_x emissions, the EDF report notes a 30 percent increase in nitrate drainage into the Chesapeake Bay during the period 1974 to 1981 (page 10). This illustrates the difficulties involved in developing source apportionment estimates: a 30 percent increase in observed nitrate drainage apparently occurred during a period of no significant change in atmospheric emissions.

The Interim Assessment also reports on regional NO_x emissions projections developed by a variety of organizations (see Figure 2). One of these, the ANL analysis using National Energy Policy Plan V assumptions, appears to have been used by EDF as the basis for its NO_x projection. The uncertainty in these projections is large because they reflect assumptions about society for the next 50 years. The projections are highly sensitive to these assumptions. NAPAP has not identified a most likely case, but all three projections in Figure 2 indicate an increase in NO_x emissions over the coming decades. However, emissions projections which assume more widespread use of better technologies project a much smaller increase in emissions of NO_x (Interim Assessment, pages 3-17 to 3-23).

Emission estimates for natural sources of NO_x have large uncertainties; these estimates must be examined with great caution. These emissions originate in soil (about 2/3 of the national total of natural emissions) and lightning (about 1/3 of the total). On a national annual basis, NAPAP has estimated that these natural emissions are 12 percent of the total emissions. This percentage is expected to vary by season (higher in the summer) and by region (higher further south). The uncertainty about the absolute value of the annual national estimate is at least a factor of three. A preliminary regional seasonal inventory is expected to be available in autumn 1988. Unlike those of sulfur, the natural emissions of NO_x may be large enough so that source attribution cannot safely ignore their existence.

Wet Deposition

NAPAP and other organizations have sponsored a network to collect and analyze wet atmospheric deposition. The data collected by these networks are the foundation for the deposition rates cited by EDF in their report. The network provides a basis for temporal and spatial descriptions of wet deposition and its components. The Interim Assessment describes the 1980 to 1984 annual composite of nitrate and ammonium ion concentrations and deposition (see Figure 3) which are summarized in the following table:

	Chesapeake Bay	U.S. Atlantic Coast Maximum	U.S. Atlantic Coast Minimum
NO3- as N (mg/L)	0.3	0.3	<0.2
NH4+ as N (mg/L)	0.2	0.2	<0.16
NO3- as N (kg/ha/yr)	3.4	3.4	<2.3
NH4+ as N (kg/ha/yr)	1.9	1.9	<1.6

Approximate 1980 to 1984 Annual Composite Wet Deposition and Concentration information adapted from isopleth maps in the Interim Assessment (pages 5-50 and 5-51).

In the eastern U.S., nitrogen deposition and concentration from both nitrate and ammonium ions is at a peak over the eastern Great Lakes and decreases in all directions.

Deposition has substantial seasonal variability. In the warm period (May through September) nitrate ion concentration in the Chesapeake Bay region is 1.5 to 2 times that of the cold period (November through March). Ammonium concentration in the warm period in the Bay region is 2 to 3 times that of the cold period. (Bowersox and Stensland, 1985).

Using data from 44 stations in the eastern United States, the Interim Assessment shows that both deposition and concentration of ammonium and nitrate ions in wet precipitation have remained roughly constant in the period between 1978 and 1984. Some eastern monitoring stations record a specific upward or downward trend, but the two stations within the Chesapeake Bay watershed (both in Pennsylvania) report no statistically significant trend.

Dry Deposition

Routine monitoring methods are not available for the measurement of dry deposition. Even the research methods in use have considerable uncertainty. Nonetheless, there are some general conclusions that can be drawn about dry deposition:

1. Deposition measurements in open buckets (i.e. bulk deposition) do not necessarily represent a lower bound on total deposition of nitrate. The open bucket technique may overestimate the deposition of nitrate associated with large particles and underestimate the deposition of nitrogen in small particles. It is not clear what its measurements represent for gaseous nitrogen. Therefore no general conclusions about the representativeness of bulk deposition with respect to total deposition can be made. No intercomparisons between open buckets and more credible methods have been published for nitrogen, but Dolske and Gatz (1984) showed that at their site bulk sulfur deposition as measured in open buckets overestimated dry deposition by a factor of two to three.

2. Current research suggests that the ratio of dry to total deposition varies with the season. In the Interim Assessment (pg 5-102) dry deposition of nitrogen to a forest was reported at 42 percent of total deposition during the dormant season, and 30% during the growing season.

3. Dry deposition varies with surface type. For a given air concentration and certain stable meteorological conditions, the deposition of NO_x to a forest can be considerably larger (by a factor of 30) than for open water (Voldner, Barrie and Sirois, 1986). However, for other meteorological conditions, the dry deposition of nitrate to open water may be approximately equal to that in forests.

COMMENTS ON UNCERTAINTIES IN THE EDF REPORT

Few decisions, let alone complex decisions involving the management of nitrogen from multiple sources throughout 64,000 square miles, are made with certainty. However, assessments which are intended to provide a basis for policy decisions should characterize the uncertainty of the information so that decisionmakers are aware of the limits of scientific information. The EDF report discusses some uncertainties, but these are not brought forward into its analysis of source apportionments or other general conclusions.

Our comments on uncertainties in the EDF report can be summarized under three major headings:

1. Constancy of processes across time (including years and seasons) and across space;

2. the relationship of dry deposition to total deposition;

3. terrestrial and fluvial ecosystem assimilation of nitrogen deposition; and

CONSTANCY OF PROCESSES OVER TIME AND SPACE

Calculations in the EDF report generally assume that processes operate in a constant fashion in time and space when in important ways they do not. Ignoring this variability can lead to biases in resulting estimates of the relative importance of atmospheric nitrogen deposition. Some specific examples are:

Year-to year variation in wet deposition data - EDF selected the year 1984 to use as a basis for developing its estimates of deposition for the Chesapeake Bay watershed. However, 1984 was a rainy year. Thus atmospheric deposition to the Chesapeake Bay area for 1984 was the highest in the period of record for the NADP stations in the area. Using average values for the period 1982 through 1986 would decrease the estimate of the deposition of nitrogen by between 11 and 20 percent.

Seasonal variability in nitrogen assimilation in forests - The EDF study assumes that forests consume 80% of the nitrogen deposited on them by the atmosphere. This assumption is between high estimates of 97 percent reported for the coastal plain, and estimates of 66 to 79 percent in forested watersheds of Tennessee. However, long-term studies at Leading Ridge, Pennsylvania (a watershed research site in the Susquehanna Watershed, at a site selected to be typical of Pennsylvania Valley and Ridge Forests and the site with the highest nitrate deposition of any NADP station) suggest that the annual assimilation of wet nitrate deposition is greater than 90 percent. Thus, the 80 percent assimilation rate may be too low. Further, because of the apparent seasonal variability in the response of primary production to nitrogen inputs (maximum responses were observed by D'Elia (1987) in August and more generally from June to January) the seasonal variation in forest assimilation of nitrogen should be considered. In fact, the overwhelming majority of nitrogen leaves forests in the winter and early spring. The EDF report alludes to this feature; on page 60 it states, "Nitrogen runoff from forests is also higher in early spring, especially in northern portions of the watershed, due to nitrogen input from snowpack melt, and decreased nitrogen retention due to frozen ground and absence of growing plants." Thus, because the Bay has seasonal variability in its sensitivity to nitrogen inputs, the seasonal figures for forest assimilation of nitrogen should be used.

Seasonal variability of wet deposition - Wet deposition of nitrogen varies seasonally as described previously. Depostion loads and concentrations are higher in the summer than in the winter. This seasonal variability needs to be considered together with seasonal assimilation factors to provide more useful estimates of nitrogen balances in the Bay.

Seasonal variability in fertilizer applications - The EDF report implicitly assumes that fertilizer is applied and washed out of agricultural lands at a constant rate throughout the year. This is highly unlikely. The bulk of nitrogen fertilizer is applied in the growing season, and nitrogen leaching from these systems probably lags slightly behind this fertilizer application. Again, because primary productivity may only be seasonally limited by nitrogen, the seasonal pattern of fertilizer runoff should be considered.

In summary, the absence of analyses on the temporal and spatial variability of the major processes controlling the input to and use of nitrogen in the Bay suggests that significant uncertainty remains regarding the contribution of atmospheric nitrogen deposition to eutrophication of the Bay.

THE RELATIONSHIP BETWEEN DRY DEPOSITION AND TOTAL DEPOSITION

Dry depostion varies profoundly with surface characteristics. Some of the characteristics of nitrogen dry deposition are discussed above. In terms of the EDF report, the major difference between terrestrial systems and open water in dry deposition is crucial. The references cited by EDF which provide a foundation for equality between wet and dry deposition are largely based on research at forested or other terrestrial sites. However, published data (Voldner et al., 1987) suggest that the dry deposition of NOx as a gas to open water is significantly less than to forests. If the dry deposition of nitrogen to open surface waters is less than assumed, then atmospheric nitrate deposition would contribute less than EDF estimated to the total in the Bay.

ECOSYSTEM ASSIMILATION OF NITROGEN

Assumptions about the rate of assimilation of nitrogen by terrestrial and aquatic ecosystems are also key to the nitrogen balance developed by EDF.

Terrestrial Ecosystem Assimilation of Nitrogen

The EDF report makes numerous assumptions about the assimilation rates of nitrogen by terrestrial systems. These include forests (63% of the total area in the Bay watershed), crop land (18%), pasture land (17%), and urban areas (3%). The use of single values without lag times for each of these systems could make a significant difference in understanding and managing the nitrogen cycle in the Bay. Our most serious concern is to question whether the rate of nitrogen passing through forest, crop, or pasture ecosystems is related to the rate of nitrogen deposition. The nitrogen cycle in forests is complex and is driven by many factors including forest successional stage, soil type, season, and forest type. However, EDF does not argue, nor has it been demonstrated elsewhere, that a change in atmospheric deposition would change the rate at which forest pools of nitrogen break down and pass out of the watershed. Thus, it does not follow that a change in atmospheric deposition to forests, crops, or pastureland would necessarily be reflected in a similar change in the nitrogen content of the receiving surface waters.

Retention of nitrogen in rivers

The EDF report assumes that 50% of the nitrogen entering Bay tributaries stays in those tributaries. According to the report, this is based on watershed models developed by EPA in the Chesapeake Bay program. It should not apply as a constant throughout the length of a tributary. Nitrogen entering the headwater of a tributary will generally have a lower probability of entering the Bay than nitrogen entering the tributary closer to the Bay. If nitrogen assimilation in a river is proportional to the length of the river traveled to the Bay, then geographic patterns of sources are important. For example, in the Susquehanna watershed nitrogen deposition is greater further from the Bay (see Figure 3A) while population density is greater closer to the Bay. This geographic pattern may bias the EDF apportionment of nitrogen to atmospheric deposition and away from other anthropogenic sources of nitrogen.

OTHER ISSUES TO CONSIDER IN THE FORMULATION OF POLICY

1. Trade-off between atmospheric nitrogen depostion and rates of fertilization of crops and forests. Nitrogen is a plant nutrient. If farmers apply nitrogen to crops according to the needs of the crops, then any reduction in atmospheric deposition of nitrogen would be offset by an increase in fertilization, or would result in reduced crop productivity. .

2. Cost effectiveness of additional highway vehicle controls for nitrogen. Existing standards of NO_x control on automobiles (0.6 grams/km except 0.4 in California) are already fairly stringent. Significant further reductions (below 0.4 g/km) appear unlikely without some fundamental new technology and/or alternate fuels. Conversion to methanol could reduce NO_x emissions by one-third or more for gasoline-powered vehicles and by one-half or more for diesel-powered vehicles. (Interim Assessment, page 2-90)

3. Trade-off between some methods of sulfur control and nitrogen control. Strategies for combined control of NO_x and SO_2 from stationary sources involve important timing issues. Many of the currently available SO_2 retrofit technologies (scrubbers) do not achieve significant NO_x reductions. Retrofit and repowering technologies currently in development or demonstration have the potential for more effective control of both species.

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FIGURE 1

From the Interim Assessment - Page 1-23

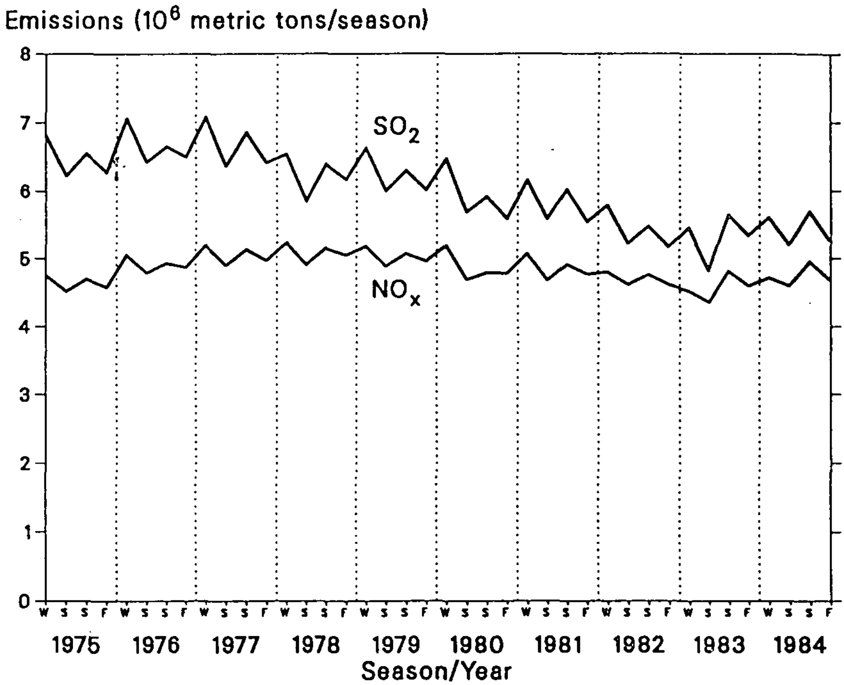

Figure 1-11.–Total man-made emissions of SO_2 and NO_x in the United States, by season: 1975 to 1984.

Note: For each year, the seasons are presented in the following order: Winter = December, January, February; Spring = March, April, May; Summer = June, July, August; Fall = September, October, November.

Source: Knudson, 1986.

FIGURE 2

From the Interim Assessment - Pages 3-28 and 3-29

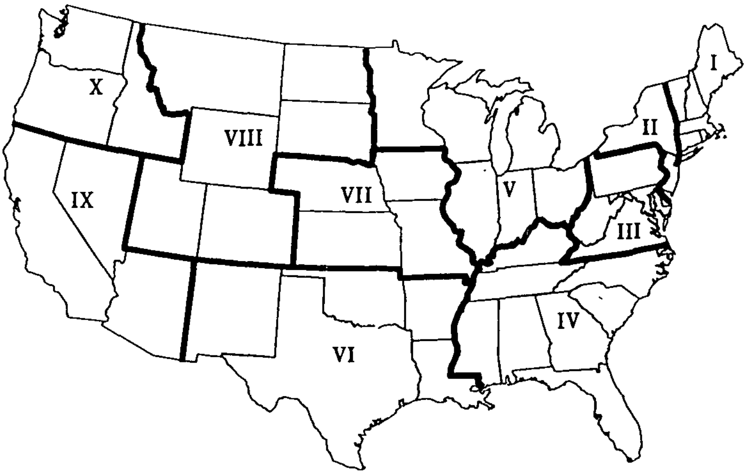

Figure 3-17.—Federal regions of the United States.

Table 3-5.—Long-term changes in regional NO_x emission patterns.

	ANL/NEPP			EHP/EPA/A			EHP/EPA/B		
	EMISSIONS		% CHANGE 1980–2030	EMISSIONS		% CHANGE 1980–2030	EMISSIONS		% CHANGI 1980–2030
FEDERAL REGION	1980	2030		1980	2030		1980	2030	
I New England	0.52	0.71	37	0.80	1.29	62	0.80	1.28	61
II New York/New Jersey	0.95	1.50	58	1.21	1.61	33	1.21	1.57	30
III Middle Atlantic	1.90	2.62	38	2.10	2.74	31	2.10	2.96	41
IV Southeast	3.26	5.33	63	3.68	6.17	67	3.68	6.25	70
V Great Lakes	3.91	5.07	33	4.09	5.66	38	4.09	6.05	48
VI South Central	2.70	4.74	76	3.99	6.61	66	3.99	6.62	66
VII Central	1.17	1.41	21	1.22	1.51	25	1.22	1.59	31
VIII Mountain	0.75	1.14	52	0.92	2.21	142	0.92	2.28	149
IX West	1.35	1.91	41	1.70	2.38	40	1.70	2.40	42
X Northwest	0.44	0.79	80	0.57	1.71	202	0.57	1.67	194
Total	16.9	25.2	49	20.2	31.9	58	20.2	32.7	61

Emissions expressed in 10^6 metric tons/yr.

Sources: E.H. Pechan & Associates, Inc. 1986; Placet et al. 1986.

FIGURE 3A

From the Interim Assessment - Page 5-50

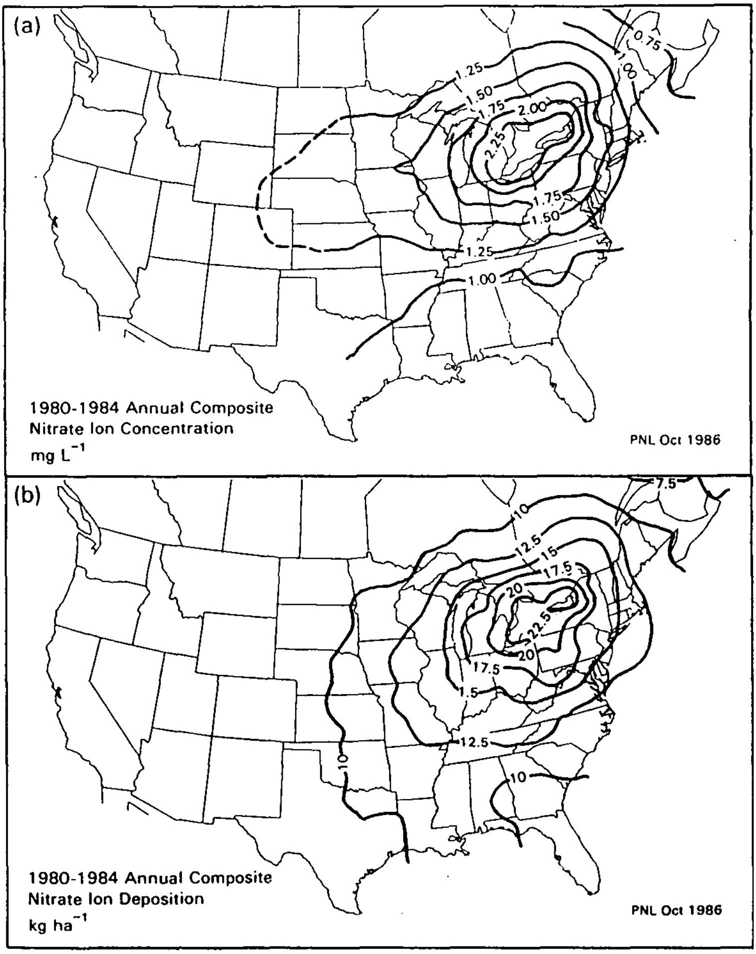

Figure 5-39.—The 1980-1984 annual composite distribution of NO_3^- (a) concentration and (b) NO_3^- deposition.

FIGURE 3B

From the Interim Assessment - Page 5-51

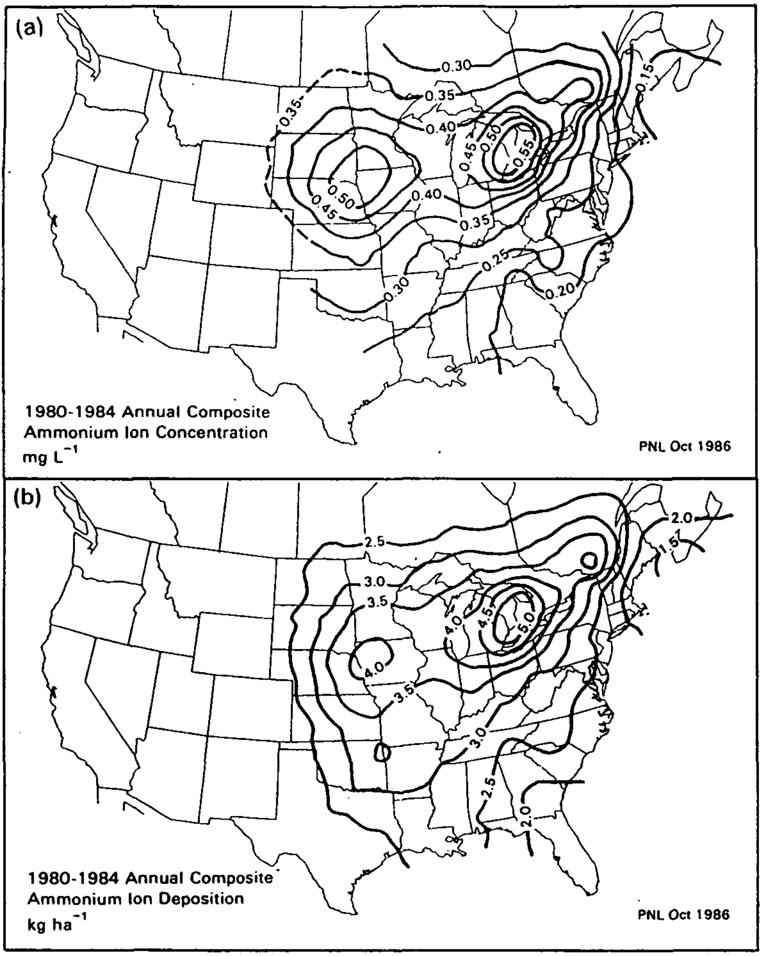

Figure 5-40.–The 1980-1984 annual composite distribution of NH_4^+ (a) concentration and (b) NH_4^+ deposition.

Senator KERRY. I appreciate it. I did not mean to interrupt. I thought you had come to the conclusion there.

The interim assessment which you referred to in your testimony that came out last year was the result of about 300 million bucks of research and five years of effort. It filled four volumes and 900 and some pages, with a 100 page executive summary.

And almost none of it focused on marine ecosystems and on this particular problem. Why is that?

Mr. MAHONEY. NAPAP at the time of its organization and in all of its early planning exercises and its reports back to the Congress during the years that you reference—that is, from the beginning of the development of its first research plan in 1982 and beyond—focused strongly on the sulphur deposition issue, not to the exclusion of nitrogen, but the principal concern was with acidification rather than nutrient loading or eutrophication in the bays.

I believe, viewed in context, that was seen as the priority issue, and in fact one of the benefits of the research conducted by NAPAP and many other programs during these past several years has been a rounding out of the view of what are the important causes and effects of acid deposition.

The EDF material calls on the NAPAP field data at many points. And therefore, I think what we have seen is an early focus on the acidification effects. That was the driving force as we understood it behind the legislation in 1980. It was strongly reflected in the original research plans and in every update to that plan and effectively in the budget hearings that were conducted each year on the ongoing field programs of NAPAP.

But you are correct, Mr. Chairman, that there has not been in that work up until this time a focus on the eutrophication issue.

Senator KERRY. Is there intention to do so?

Mr. MAHONEY. Yes, sir. In my statement submitted for the record here today, we indicate that we will take note of this report and other similar studies. And in the context of our plan to publish for review a comprehensive planning document relative to our final assessment, we intend to note this and note our approach to survey and analysis.

And we also intend to invite comments from all interested groups. I would have to assume that EDF would continue its interest in that context when that plan is published for review in about three months.

Senator KERRY. I appreciate enormously and I think everybody does, your acknowledgment of the relationship and of the importance of the report, while you may question some of the assumptions, and the percentages. Getting to that, assume you accept or assume we accepted your assertion that there is some room for question as to whether it is 25 percent or 20 percent. You may have a shift, is what correct, according to the level of runoff or whatever?

But assume you take it at 20 percent. If you low end it according to all assumptions, do you agree that this is a serious enough issue that you cannot solve it by simply addressing the question of pesticide, herbicide, agricultural contribution, but you have got to address, if that were true, the NOx reduction issue also?

Do you accept that?

Mr. MAHONEY. Sir, can I respond in two parts. I would like to comment on the characterization of the percentage first and then go on to the question of the importance of this as a source.

As an overall percentage, I have two concerns speaking as a scientist. One, I am not prepared to accept 20 percent as the lower bound yet. I do not have a firm number, but in my own general view it might range anywhere from, say, on order of ten percent up to over 30. I do not dispute the upper bound, but I do not believe we have enough examination of the background to say that the whole range of uncertainty is only between roughly 20 and 30 percent right now.

Second, as a scientist, anyone dealing with nitrogen and the whole ecosystem, terrestrial, aquatic, coastal and the like, is well aware of the massive complexity of the nitrogen balance problem, including the fact that in many cases annual and decade long changes in nitrogen fluxes relate to forest decline and the decay of organic material and the like.

So I have to cite those things as cautions, because I think otherwise we can jump to a too easy conclusion. With that concern, speaking on the technical issues, I certainly agree, and it is consistent with what the statement says, that atmospheric deposition is one significant route of introduction of nitrogen to the coastal systems. And therefore certainly deserves attention.

Senator KERRY. Now, following through on what you said then, from the public policy perspective, sitting here as a legislator, and concerned about this particular system, if, I am told, that acid rain could be as much as 30 percent of the problem, is there a responsibility that we have to respond to that possibility, given the fact that if you wait 10 years at 30 percent, given the other contributions, you may in fact have the eutrophication of the system, whereas if we move now we safeguard against that possibility.

I mean, do we have a responsibility to react to the possibility that the number is 30 percent? Or do we have to wait until there is a certainty as to its being 22 percent or 25 percent?

Mr. MAHONEY. I certainly think it is appropriate to give this strong attention now. I make a distinction between careful and rapid evaluation and definite action as to control.

I would rather not comment on the social and economic aspects of control. But I view the broad question there, of course, is a commitment of resources to these controls versus others. And therefore, I do not think it is appropriate for me to simply state that I think this deserves action right now.

Senator KERRY. What priority efforts are being given to trying to better resolve these percentages—given the potential for 30 percent.

Mr. MAHONEY. I will speak very briefly, and I would ask Mr. Linthurst to speak about that, because EPA has a lead in terms of the whole national estuary program series of activities. These involve the Chesapeake Bay and others.

NOAA also has a major responsibility and a lead on some of these programs through the Sea Grant Program. And we have to remember that when we look at the problem of protection of the Bay we really need to take that focus rather than simply the focus of acid rain. And that is the reason that it is more appropriate that the overall management focus comes through those other programs.

And Rick, I think it would be more appropriate for you to speak about EPA's activity.

Mr. LINTHURST. Yes. The Chesapeake Bay Program, which is continuing now with a variety of Federal agencies and the states, is in fact trying to look at these source apportionments.

I think their models are being approved. The models now include estimates of runoff, trying to determine how much is retained in the watershed, but continue to have large uncertainties because of the uncertainties associated with the retention factor.

But I think those models and the research and monitoring going on in the Bay will address that issue.

Senator KERRY. What is the timeframe on that? Do you have a sense?

Mr. LINTHURST. I believe that they are in the second phase of a several phase program, and I think over the next two to three years they will have much better information in terms of source apportionments and what they think the contributions are.

Senator KERRY. Is there no way to do that faster?

Mr. LINTHURST. I guess it goes back to the question of how much certainty is required. I think as we had already indicated here, the numbers provided in the report are reasonable with the data available, and it depends on how much refinement is desired for that particular analysis. An increased refinement would take more time.

Senator KERRY. That really depends on the model structure, does it not, more than anything?

Mr. LINTHURST. I think that if there is an effort to accurately depict the Chesapeake Bay system in a model that really represents all the processes, et cetera, there is a fair amount of research that needs to go into developing the components of the model or improving components of the model.

Senator KERRY. Have you done any kind of economic assessment on the damage being done to the Bay right now?

Mr. LINTHURST. I personally am not aware of those types of analyses.

Senator KERRY. Is there any analysis of the economic damage as a result of nitrogen loading as a whole in the Bay?

Mr. LINTHURST. Not to my knowledge.

Senator KERRY. Would it not be valuable to undertake something like that, given its value to the six state region?

Mr. LINTHURST. Let me clarify that I personally am not aware of these analyses. I personally do not know whether they exist.

I would suspect that the Chesapeake program participants have evaluated the economic aspects when they signed the agreement in 1987 as they needed to know what the cost of the controls were going to be. So they may exist, I am just personally not aware of them.

Senator KERRY. Well, it is my understanding that EPA over the last few years has been doing a study similar to the EDF study with respect to acid deposition effect on marine ecosystems. Is that accurate?

Mr. LINTHURST. That is correct.

Senator KERRY. Do the results of your study that you have at this point in time, you have, concur with those by Dr. Fisher and EDF?

Mr. LINTHURST. I think they concur in the sense that nitrate loadings from the atmosphere is a significant fraction of the total.

Senator KERRY. If that is true, given everything else that we have learned, does that not create some compelling rationale for moving on one or both?

Mr. LINTHURST. I believe the implementation plan that the states have developed does take action but, I do not know what the effect will be of that plan.

If they reduce nitrate by 40 percent by the year 2000 in the Bay or discharged into the Bay, as they are planning to do, I do not know what the level of nitrate would have to be to improve further or protect fully the Bay.

Senator KERRY. Well, I can understand. I totally agree with that, and I understand that. But are we not at a point where you have got to begin somewhere?

I mean, we all know what no reduction is going to do, do we not?

Mr. LINTHURST. With no reduction, we are going to continue to have the deposition that fraction of nitrate going into the Bay. But it is again a question of whether the 40 percent reduction that has already been agreed to going to be enough.

Senator KERRY. Do the percentages from your study for the amount of nitrogen going into the Bay concur with the EDF study?

Mr. LINTHURST. As I recall, they are somewhat lower at the lower bound.

Senator KERRY. Yours are?

Mr. LINTHURST. Yes.

Senator KERRY. Do you know how much?

Mr. LINTHURST. My understanding is that it might be somewhere around 13 percent, as opposed to their estimated 21 percent.

Senator KERRY. And what is the uncertainty of that estimate? Do you know?

Mr. LINTHURST. Well, as uncertain, I guess, as we have been discussing here. The input data that is required for these kinds of analyses in many cases just is not readily available.

The uncertainty estimates for how much fertilizer is used what are the true runoff rates, and is an average field an adequate type of calculation to make, and so on are large. It is just going to take some time, I think, to get really good refinements.

Senator KERRY. And your upper bound?

Mr. LINTHURST. I would feel more comfortable with a lower bound. I cannot object to the upper bound. I have no reason to believe that it would be any different than what they have suggested.

Senator KERRY. Senator Stevens?

Senator STEVENS. I just have a few questions, Mr. Mahoney. In your statement you say this: "Decisions on effective controls for eutrophication in coastal waters, including possible reduction of nitrogen oxide emissions, can be best made when the following actions have been taken."

And then you list establishment of goals for long-term loading of nutrients, the resolution of significant uncertainties and contribution of atmospheric nitrate, and evaluation of the practicality of cost effectiveness of various control approaches involving a mix of fertilizer, et cetera.

Now, that is the first time that I have heard anyone suggest the concept that we should delay taking any action at all until we define the most effective controls. Do you have any timetable for those actions? When could we expect those actions to be taken?

Mr. MAHONEY. I believe all of those actions, in fact, are in process, Senator. It is not a simple matter to give a single timetable because I do not view that a consensus has formed about these issues because any one report is laid down.

Senator STEVENS. That was going to be my next question too. You indicate you believe we ought to delay. Are you really serious? Should we delay those decisions until all these actions have been completed?

Mr. MAHONEY. It is not a question of waiting till they are completed, assuming that that is a chain of analysis that goes on forever.

I am not proposing that as a surrogate for arguing for delay. I am proposing the importance of really understanding what the critical loading issues are in the Bay as the responsible first step toward deciding where to invest to get the best and the most effective controls. That kind of work is underway, sir.

Senator STEVENS. I do not want you to interpret me being antagonistic. I think you could be misquoted here if we do not probe this now, because you are really not saying that we should not take action on the assumptions that are being used, or the basis of the assumptions of these studies that are being presented to us now.

You are not saying that you want a delay on acid rain legislation or clean air or anything like that. Am I right?

Mr. MAHONEY. I am not specifically recommending delaying there, sir, that is correct. In this testimony I was trying to focus on the issue raised about how to make effective improvements in the Chesapeake Bay and similar waters.

And the sense of my comment is that I think everybody analyzing the problem realizes that the Chesapeake and other similar ones, the Chesapeake is probably the best example, is a very challenged Bay, it is a very complex system.

A key first step has been taken with the interstate compact aimed at the 40 percent reduction in runoff. Now, atmospheric levels, if they run at the same level or if the emissions change even a little bit, which is as much as they go in either direction regardless of legislation over the next few years, will still make basically the same contribution it is making.

I think that we now see a focus on the importance of the atmospheric component. And the sense of my advice there is that that whole system is complicated enough that it is not, to me, responsible to recommend overt expensive control actions until we have some reasonable debate about the benefit that would come from it.

And I think that kind of analysis and debate is something that is in front of us now, and I would presume with the ongoing studies over the next several months and the next year we will have a much sharper view of that.

Senator STEVENS. You think we ought to be able to make these decisions that you say ought not to be taken until these actions have been completed, within a year or two?

Mr. MAHONEY. Yes, sir.

Senator STEVENS. And you think that there is sufficient uncertainty. You mentioned the uncertainties, and the resolutions, in the estimates of the contribution of atmospheric nitrate to total nitrogen loads. You think there is enough uncertainty there to warrant that delay?

Mr. MAHONEY. Yes, sir. But if I can explain why. I have a different view about the atmospheric control problem too.

Right now, in my view, as a Nation, we are looking at very serious questions of commitment to new levels of control for all of the atmospheric pollutants. You have it all before you here in the Congress, in both houses in fact: the choices of the controls to be preferred.

That is, the importance of sulfur oxide controls, which clearly have a key role in acid rain. Nitrogen oxide controls imply different levels of expenditure, different kinds of control technology, whether to favor current generation sulfur scrubbers for major power plants and industries, for example, or whether to try to favor enhanced development of combined SO_2 and NOx technologies and bring those on a few years later for different purposes.

We have a much more rich view of these interconnections now than we had a few years ago where, in my view, most of the arguments about acid rain control would have knocked down the sulfur problem and assumed that we were largely through with it.

Now that we have developed this, I think that it is very important that we really understand the options and basically get the best control for the monies we spend finally, out of a whole series of control options and control technologies.

So it is in that sense of the broad atmospheric strategy issue that you all in the Congress are facing what I think of as a boundary problem. We are talking about acid rain and the nitrogen component of it being one component of eutrophication burden in the bays.

And when I focus on that alone, I have tried to express caution that we want to be careful about jumping on controls for that by themselves without a careful view of the whole series.

And I am trying to be very clear, I am not arguing that caution is a surrogate for no action. I am not saying, let us just keep studying, but rather that we do see this complexity.

It is the kind of thing we are trying to draw together on the acid rain side and our NAPAP assessment, to explore these ranges of technologies and the ranges of improvements expected from the various choices so that we have a basis to measure in the end, so that we know the kind of investment that is expected and the kind of benefits we expect from that investment.

Senator STEVENS. Well, for several years now some of us have been meeting with the Canadians in parliamentary conferences. And the Canadians are very strong on telling us that we have delayed too long, that they want some action now.

Would your comments go to the overall question of acid rain per se? Are you saying that you do not think we know enough yet about the contribution of acid rain to this overall problem of these nitrogen oxide emissions?

Mr. MAHONEY. Sir, I think we know much more about the effects of acid rain than we did, say, three or four or five years ago, through the government sponsored studies and many other things.

I think our views have sharpened a great deal, and I view that the major remaining question for us is the analysis of what kinds of benefits we want to bring about, where we want to cause improvements in the loadings of both sulfur and nitrogen, and what kind of scenario of technologies we want to adopt to get that.

Senator STEVENS. Do you think we are close to developing that—an ability to analyze the types of controls proposed as to what effect they will have and what the economic impact of the controls would be? Do you think we are close to that?

Mr. MAHONEY. Yes sir, I do. And the reason is that I think we have had study for a long time, and I am well aware that studies can go on forever.

It is a question of whether there is a real step point where you say, we now know enough or know more than we did earlier. I think one way to cite a simple example of that is on the question of the use of scrubbers, for example, for SO_2 control.

If as a Nation, and if you all here decided to adopt a legislative approach that would argue to get strong SO_2 reductions very quickly, one likely effect of that would be the imposition of scrubbers on many existing facilities.

Many of the existing scrubber technologies do not get much of the NOx out, the nitrogen oxides. So if you were to adopt that now, or if hypothetically that kind of requirement had been adopted here in the Congress, say, two or three years ago, we would be investing in very expensive controls that might not address this nitrogen problem much.

And by comparison, if there is a time scaling of our investment in technology, we have major technology development programs now well under way, and in fact in large-scale demonstration, that are combined SO_2 and NOx emission reduction technologies.

My view is it is important to understand the economic implications of adopting those technologies. The benefits that would come from those and the comparison between that and, for example, what I would argue is a rapid adoption of SO_2 technology that might close the door to the use of the combined control technologies a few years later.

Senator STEVENS. That is very interesting. Thank you very much.

Senator KERRY. Senator Danforth?

Senator DANFORTH. Any clean air legislation is very difficult to enact. It is prone to regional divisiveness. It would really take a clarion call, I think, to move forward in this issue. I take it the clarion call just is not there.

Mr. MAHONEY. Sir, the position that we are trying to carefully adopt in the national program in NAPAP is that it is very important for us to be responsive to the mandate of the original legislation, and I think the continued development of the importance of understanding the science and the technologies and the economics of these controls.

NAPAP, as a special program created by Congress and overseen by Congress over the years, does not have to become one more voice in arguing for one or another regional control. We are well aware of those issues as citizens and people who read the newspapers.

But we do view that our role is, and our mission is best served, if the program is not seen as an advocate on those matters of public value, of job impact and economic impact in one area or another, but rather that NAPAP can look at all of the information and organize it and present as credible information as possible about what are the real effects we see, try to get through some of the levels of rhetoric.

There is a place for rhetoric, but there is also a place when we are talking about major investments to say, just how widespread are the effects we can actually document? And what kind of improvements would we expect with various kinds of investment and change?

That kind of thing we are trying to do, not as a particular policy position, but as the responsible job of doing as much to look at the whole thing as possible. We certainly understand that any controls actually adopted will come out of the normal pressure of policy debates, as that should happen, through the Congress and the Nation more generally.

But we do view our role as to give as broad a synoptic or hands-around view of all these issues as possible. And that is the kind of job that we have in hand right now.

Senator DANFORTH. Well, I understand, and I appreciate that dispassionate approach.

Do you see that at some point in time you are going to be in a position to say, all right, we have made a decision, here is exactly what we should do?

Mr. MAHONEY. I say, yes sir, all except the very last part of that. On the matter of here is exactly what we should do, I really think that embodies these public value decisions so that what we will say is, here are the advantages and costs of a series of the well understood options.

And we do intend to do that very sharply on the time schedule that we have now, in time to meet our deadlines in 1990. We have a couple of specific steps aimed toward that. The most important of which in the short term is this publication of a detailed plan for that 1990 assessment, which we will have out for general review here within three months.

The concept of that is that we are trying to say in one time and place, in this plan itself, what are all of the effects that we think are important when we talk about acid rain? What do we know about their severity? And how are we going to organize all of our information to describe the improvements or changes that would occur if various of the obvious choices were made?

So we are trying to say that first as a plan so that we can lay out the structure and the questions being posed, and we will document the kind of scientific and technological analyses that are behind that and what we are doing.

We will be asking for comments from everybody about that, from the interested industrial and economic development parties to the

Canadians to the environmental groups. And of course, to you all and your staff.

And then we are putting together all of the information that comes out of this long program into the structure which that plan represents, so that as we deliver it in 1990 we will have the best effort hopefully that can be made in any case to try to put it together and view all the matters.

Senator DANFORTH. Thank you, Mr. Mahoney.

Thank you very much, Mr. Chairman.

Senator KERRY. Thank you, Senator.

I am just a little confused, but I want to call your attention to an article in "Science magazine," March 1987, You have pointed out in your testimony about the consistent level of NOx emissions, and there may be a discrepancy you can explain. But it says here, at any rate, that:

"In addition to agricultural runoff, atmospheric deposition has become a major source of nitrate in surface waters, especially in forested basins of the East and northern Midwest. Few nitrate deposition records exist for the years before 1980, but those that do"—and he references them—"together with emission estimates of nitrogen oxide, show a general pattern of increasing rates during the 1974 to 1981 period."

Are we just taking data from two different sources? Do we disagree or what?

Mr. MAHONEY. First of all, Senator, I am not familiar with that article in particular. I would be glad to review it and respond further.

I can tell you what I would guess is the point of discrepancy at this time. The NAPAP data, which is figure 1 in my prepared statement and which is from our interim assessment documents, one of those 900 pages, is in my view quite reliable as to emissions, and that data was developed on a three month by three month basis through that whole period.

We do know without any question that nitrogen oxide emissions have increased very rapidly in the whole postwar era in the United States, from 1945 forward; and that in fact the first leveling of nitrogen oxide emissions was in the early seventies and continued on until about the middle eighties.

And that was the effect of the first rounds of the Clean Air Act restrictions, especially on motor vehicles.

Senator KERRY. Now, I was interested in your exchange with Senator Stevens. Your approach seems to be one of not investing in controls now because we may invest in controls that are too expensive or unnecessary.

I almost feel there is a kind of micromanagement approach, which is so inconsistent with all the complaints we consistently hear, which are: do not micromanage these kinds of things; let the marketplace determine it; put your controls out there and let the technology develop; let people recognize there is a demand.

And in fact, that is precisely what Germany did. When I was in Germany and I met with the equivalent of their associated industry leaders, I was dumbstruck to find that not only did they willingly go along with and adopt the notion of retrofitting, but they did it without any tax credit, without any deduction, without any Federal grants whatsoever.

Every company went out and capitalized its retrofitting. And I asked the president of this organization, if there was not a struggle with this. He said: "No. You know, we recognized that our forests and our country were at stake, and we did it, and the market took care of it."

You know, I am sort of stupefied that here we are ignoring what Norway has done, we are ignoring what England has done, we have ignored the European compact, the Soviet Union and others.

And we are still saying: You know, we do not want to spend too much money on this or that. And here you are with near-eutrophication of a major national asset. Now, how do you balance that? I have great difficulty understanding that.

Mr. MAHONEY. First of all, my comment about the difference between preference for sulphur oxide and nitrogen oxide controls I would not want to confuse with an argument to micromanage the broad level of requirement for reduction. Whether Congress should adopt a bill aiming largely at SO_2 alone or both at sulphur and nitrogen and in what proportions is not micromanaging. That is a very broad-scale issue.

I have spent a fair amount of time working as an advisor in Europe over the last 20 years, and I am very struck with the much lower level of adversarial relationship which exists between government, universities, and industry, and other public action groups, leaving out some of the extreme ends perhaps, in most of the European countries.

And in my personal view, it is simply a very different public culture than we have here in the States.

My argument about watching carefully that we do not require sulphur oxide controls and close the door to NOx controls if we need them is not meant to argue that we have to delay that process or that we should not spend where we need to.

I am not trying to argue one way or the other about that, but just to show that the question of the strategies to adopt is a really key one. The Germans have basically adopted a sulphur oxide control strategy. We might have done that years ago. Had we done that, we might—that strategy would not produce any significant benefits relative to the problem here being discussed today.

Senator KERRY. I understand that. But they are linked attitudinally and they are linked in terms of just a general outlook on the whole issue of control and study. If you look at the problem of the Chesapeake, as I understand it—and I am still learning about it—you have two contributing factors in the eutrophication, do you not? One is the nitrogen loading; the other is phosphorus, correct?

We are trying to deal with the phosphorus, so that leaves you nitrogen. So then you look at the sources of nitrogen. Now, if 25 percent of your nitrogen problem is acidic deposition and the others are, what, agricultural runoff and there is one other——

Mr. MAHONEY. Beyond the 25 percent, the rest is fertilizer, animal wastes, and generally speaking other organic components, the decay of pasture land and forests and so forth, and sewage in particular.

Senator KERRY. Now, there is none of them that does not present a significant expenditure and tradeoff problem. Accurate?

Mr. MAHONEY. Yes, sir, definitely.

Senator KERRY. And I was somewhat struck in your testimony that you even suggested that one of the restraints here on moving forward was the notion that there is a tradeoff between atmospheric nitrogen deposition and rates of fertilization of crops and forests.

Quoting from you: "Nitrogen is a plant nutrient. If farmers apply nitrogen to crops according to the needs of the crops, then any reduction in atmospheric deposition of nitrogen would be offset by an increase in fertilization or would result in reduced crop productivity."

Now, it seems smarter to me to be putting your fertilization where you want it, rather than relying on a deposition system that puts it everywhere.

And what I get out of that is a sense that you are trying to find all the reasons for going slow here, rather than looking realistically at what the tradeoffs are. I mean, where is there a cheaper nitrogen reduction effort? Can you tell me that?

Mr. MAHONEY. I believe that the agricultural controls may well be cheaper if the alternative is an atmospheric control on motor vehicles, for example, which would likely be imposed nationally. And we might want it for other reasons nationally.

But a major part of the atmospheric nitrogen deposition we are talking about is that that emanates from motor vehicles. And when I think of the whole problem, I feel that, sure, we may want that, we may want it for a lot of reasons.

But if we are going to invest in national motor vehicle controls or somehow try to think up a system that would create an East Coast car which would be the equivalent of the California car under our current legislation, that kind of action is going to require a lot of puzzlement, I think, before it would be accepted.

And it is in that sense I think it is worth it to be careful. More than that, my comment about deposition, the comment that you quote, was purposely put at the end of the statement because it is an important consideration on the technical analysis of mass balance of nitrogen. I was making no policy claim about that at all, rather pointing out that when we analyze the effects of reduced airborne nitrogen we might not get all that benefit, because there might be a requirement—there will generally be a requirement for increased use of fertilizer in the region.

I am not trying to argue that as a reason to delay or that as a preferred mechanism of fertilization. But it is part of the technical argument and it is cited at the end of the statement for that purpose.

Senator KERRY. Mr. Linthurst, just quickly before we end up here—and I am going to leave the record open here for questions, because we are running tight on time here. The EDF report has asserted: First, that acid rain is a serious threat; secondly, that in the years ahead it is going to become more and more serious relative to other problems threatening the Chesapeake.

Do you concur with that?

Mr. LINTHURST. I think that it is certainly something that is going to increase over time, as best we can tell. And it is going to have to be factored in in trying to improve the bay or maintain the bay in good condition.

Senator KERRY. Do you think that this report and this issue contribute in real ways to the dialogue with respect to the overall acid rain control issue?

Mr. LINTHURST. I think it certainly contributes further evidence to the fact that atmospheric deposition of nitrate is important, and that it is obviously a factor to be considered in determining those control strategies.

Senator KERRY. Well, I certainly hope it will be—and I think I express this on the behalf of a lot of people who have been concerned with this. We have seen that Governor Cuomo and Governor Celeste have joined together. I know Governor Cuomo and Governor Dukakis early on took steps in Massachusetts.

There has been an awful lot of study on this, and I just hope that the EPA and NAPAP and others are going to join in the effort, rather than be viewed, as I think many have had a sense, that there is a reluctance to grapple with this in real terms.

But I appreciate your candor today and I appreciate your assessments. I think it has been helpful and certainly underscores some of the areas where we do need to push rapidly for some further study. And I hope that you are going to do that and work with us in the effort to try to resolve a sensible approach to all of this.

Let me ask for the third panel, if I can, at this time. Thank you very much.

I would like to welcome Dr. Charles Driscoll, Professor at Syracuse University; and Dr. Hans Paerl, University of North Carolina, Institute of Marine Sciences; Dr. Jay Taft from an obscure institution in Cambridge, Massachusetts. Welcome.

It does not matter to me who leads off. If you have a predetermined order, I would be delighted. If you just want to go left to right or right to left, that is fine, or however you want to do it.

Dr. Paerl, do you want to lead off.

STATEMENT OF DR. HANS PAERL, UNIVERSITY OF NORTH CAROLINA, INSTITUTE OF MARINE SCIENCES

Dr. PAERL. I can, Senator.

Senator KERRY. Let me ask you, if you can try to summarize your testimony, I think that would be helpful to us.

Dr. PAERL. I believe among the three of us we will talk about sources, transport, cycling of nitrogen, and fates. And my specific contribution to this morning's session will deal with fates.

First of all, I would like to thank you for inviting us to the hearing and good morning. I am Dr. Hans Paerl. I am Professor of Marine Sciences at the Institute of Marine Sciences at the University of North Carolina in Morehead City.

I appreciate the opportunity to provide you with a summary of my research on acid rain as a growing source of nitrogen nutrients in our nation's coastal ocean, including the important estuarine ecosystems.

I believe that the Environmental Defense Fund report on potential impacts of acid rain in estuaries and coastal oceans has drawn our attention to a largely ignored, but significant, property of acid rain, namely its elevated nitrogen content, which has already been discussed.

The availability of nitrogen is an important factor controlling production in estuaries and coastal oceans. It follows that enhanced nitrogen loading from any source often promotes increased biological production, at times leading to unwanted or nuisance algal growth in such waters. Hence, there exists a reason for concern.

Five years ago, I initiated a research project aimed at identifying triggering agents for the massive blooms of blue-green algae periodically plaguing water quality in local estuaries. This work was part of the North Carolina Sea Grant program and was also co-funded by the National Science Foundation.

During the course of this project, I discovered that nitrogen was a key nutrient triggering and sustaining such blooms. Accordingly, I began probing for its sources. Immediately identifiable, of course, were the point sources such as sewage treatment plants and industrial facilities, as well as traditional non-point sources of agriculture, forestry, and runoff, as well as ground water. But I also found that acid rain contributed significant amounts of nitrogen to North Carolina's Albemarle-Pamlico Sound system and adjacent coastal ocean waters.

The following conclusions can be reached from this study:

One, acid rain falling in coastal North Carolina regions contains two to ten times as much nitrate-nitrogen as non-acid rain;

Two, acid rain is a significant source of nitrogen in the North Carolina coastal ocean and estuarine habitats;

Three, acid rain-derived nitrogen is capable of stimulating algal growth in these habitats, and I attach a relevant paper which is on my testimony;

And four, the relative importance of acid rain as a nitrogen source appears to increase as we transcend from the estuarine to coastal ocean waters, and I believe this point has not really been raised yet.

Senator KERRY. It seems to increase?

Dr. PAERL. Yes. And the reason for this is related to the fact that nitrogen sources are stripped out of estuaries by the organisms living in them, and that includes runoff, as well as processed rainfall.

Rainfall, as a direct nitrogen service, deposits onto surface waters both in estuaries and coastal oceans. As a relative (relative to point and non-point sources) source of nitrogen, the importance of rainfall increases as one moves from the estuarine environment to the coastal oceans, because it can directly fall on our ocean water, whereas most of the point and non-point nitrogen sources are stripped out in estuaries before entering the coastal oceans.

So I would like to emphasize that we should look beyond our estuaries in marginal coastal waters, which we call our coastal oceans as well, because on a relative basis the actual contribution of rainfall nitrogen into those systems may be even higher than it is in estuaries. And I underline "may" because we are just beginning to look at budgets in these systems, as opposed to the well-studied Chesapeake Bay system.

In relation to the Chesapeake Bay, or other more eutrophic systems where enhanced nutrient loading has led to accelerated eutrophication and undesirable algal growth already, the additional impact of acid rain could aggravate this condition. In other words, it is an additional source of nitrogen to an already excessive amount of nitrogen available.

Potentially the impact of acid rain may range from subtle changes in algal community composition to accelerated eutrophication, potentially leading to long term undesirable water quality degradation, including blooms of nuisance algae, accompanied by local anoxia events, loss of desirable phytoplankton production—and the word phytoplankton is synonymous with algae, by the way, for the layperson—and even more devastating, detrimental food chain alterations that could include losses of economically important fish and shellfish.

This clearly calls for a research agenda, in large part because it is a fairly new phenomenon that we have just become acquainted with. And I have outlined several strategies that we could possibly take:

One, examine the relative importance of atmospheric, and that is both rainfall and dry deposition, sources of nutrients in the nutrient budget of estuaries, sounds, and coastal oceans, with an emphasis on nitrogen;

Two, examine and evaluate direct impacts of acid versus non-acid rainfall on algal species composition and algal production characteristics. In particular, attention should be focused on the potential for nuisance algal growth under the influence of different precipitation sources. Both long term and short term impacts of phytoplankton production should be examined.

And thirdly, utilizing a multi-disciplinary approach, we need to trace the fate of nitrogen derived from rainfall versus nitrogen derived from landborne sources in the coastal ocean.

Experiments in this third area are particularly instrumental in determining to what extent nitrogen nutrients are transported, utilized and ultimately responsible for altering trophic and water quality conditions in coastal oceans at locations other than at the site of input.

In conclusion, I would like to stress three points:

First of all, acid rain appears to be a significant and geographically widespread source of nitrogen in our already nutrient-stressed estuaries and coastal oceans, and we believe the problem is not only a Chesapeake Bay problem; it is a problem that stretches at least as far south as North Carolina.

Secondly, experimental results have shown acid rain-derived nitrogen to stimulate phytoplankton growth in estuarine and coastal ocean habitats. Now what we need to know is what the qualitative impacts on types of phytoplankton are, and also of course what ultimate impacts are higher-ranked consumer organisms. In other words, what are the productivity and food chain impacts in systems receiving enhanced nitrogen loading from acid rain.

Thirdly, our knowledge of the relative impacts of nitrogen from acid rain is limited at best, and we desperately need fundamental information on the sources, fates, and impacts of atmospheric nitrogen in the coastal oceans.

I would like to close by thanking you for this opportunity to share my concerns with you, and I feel you are to be commended for addressing this issue in a very timely fashion.

[The statement follows:]

STATEMENT OF DR. HANS PAERL, INSTITUTE OF MARINE SCIENCES, UNIV. OF NORTH CAROLINA

Thank you and good morning. I am Dr. Hans W. Paerl, Professor of Marine Sciences at the Institute of Marine Sciences of the University of North Carolina, Morehead City.

I appreciate the opportunity to provide you with a summary of my research on acid rain as a growing source of nitrogen nutrients in our nation's coastal ocean, including the important estuarine ecosystems, and to present testimony about how research is needed to help our nation solve its problems of managing the coastal ocean. I am presenting this on behalf of my University, and the Marine Division of the National association of State Universities and Land Grant Colleges (NASULGC) and the Sea Grant Association (SGA). The Marine Division of NASULGC is composed of 90 major marine research and education institutions in the United States. Each is committed to the understanding, conservation and development of the ocean and coastal resources. The SGA consists of 40 colleges, universities, research centers and consortia dedicated to enhancing the Nation's capability to develop, use and manage our marine and coastal resources. NASULGC is composed of 149 colleges and universities that enroll about 3 million students and grant the majority of the Nation's graduate degrees.

BACKGROUND

The recently released Environmental Defense Fund Report on potential impacts of acid rain in estuaries and coastal oceans has drawn our attention to a largely ignored but significant property of acid rain, namely its elevated nitrogen content. Previous studies have pointed out the ability of acid rain to increase acidity of poorly buffered freshwater habitats; as a result, both chemical and biological characteristics of such waters are altered, leading to losses of desirable resources. In contrast, marine waters are well-buffered against acidification following acid rain deposition. Accordingly, little concern has been expressed regarding impacts of acid rain in estuaries and coastal oceans. However, the availability of nitrogen is an important factor controlling production in estuaries and coastal oceans. It follows that enhanced nitrogen loading often promotes increased biological production, at times leading to unwanted or "nuisance" algal growth in such waters.

Five years ago, I initiated a research project aimed at identifying triggering agents for the massive blooms of blue-green algae periodically plagueing water quality in local estuaries. This work was part of the North Carolina Sea Grant Program, and served as a national priority research issue directed toward describing the role and fate of nutrients entering the coastal area. This problem, commonly referred to as eutrophication, has attracted considerable research and management interest in recent years. During the course of this project, I discovered that nitrogen was a key nutrient triggering and sustaining such blooms. Accordingly, I began probing for its sources. Immediately identifiable, of course, were the point sources such as sewage treatment plants and industrial facilities as well as traditional non-point sources of agriculture, forestry, surface as well as subsurface (groundwater) runoff. But, I also found that acid rain contributed significant amounts of nitrogen in North Carolina's Albemarle-Pamlico Sound System and adjacent coastal ocean waters.

This study yielded the following conclusions of research and management concern:

1) Acid rain falling in coastal N.C. regions contains 2-10 times as much nitrogen (as nitrate) as non-acid rain.
2) Acid rain is a significant source of nitrogen in North Carolina coastal ocean and estuarine habitats.
3) Acid rain-derived nitrogen was capable of stimulating algal (phytoplankton) growth in these habitats (please see attached paper, Paerl: Nature 1985).
4) The relative importance of acid rain as a nitrogen source appears to increase as we transcend from estuarine to coastal ocean waters.

Because a variety of studies have shown rainfall to be a significant source of nitrogen in estuaries (estimates range from 10-30% in East Coast estuaries) and coastal waters (where more than 30% of the annual nitrogen inputs may be attributable to rainfall), current trends in acidification of rainfall should be of concern from both water quality and resource perspectives. Research is needed to quantify and evaluate sources, sinks, fates and water quality impacts of acid rain-derived nitrogen.

ACID RAIN AS A POTENTIAL PROBLEM

There is considerable debate concerning specific impacts of acid rain and its nitrogen inputs. While we found that a significant proportion of available nitrogen comes from rainfall, we do not know the relative role it plays in supporting algal blooms, associated eutrophication rates and/or its relationship to re-cycling mechanisms at work in natural ecosystems.

In estuaries, nitrogen inputs are quite efficiently utilized or "filtered" by microscopic phytoplankton which in large part constitute the base of the food chain. Under circumstances where enhanced nutrient loading has led to accelerated eutrophication and undesirable phytoplankton growth, the additional impact of acid rain could aggravate this condition. Downstream of estuaries in coastal ocean habitats acid rain constitutes a direct and relatively important nitrogen source, since it bypasses estuarine filtering activities. In such situations acid rain may play a key role in determining both the magnitudes and types of phytoplankton growth characterizing coastal ocean environments.

Most attention has been focused on land-borne nutrient runoff as the principal factor involved in estuarine and coastal ocean eutrophication. Virtually no attention has been paid to atmospheric sources of nutrients, specifically acid rain nitrogen-enriched conditions. Our findings in the North Carolina sounds and coastal waters, which are not thought to be particularly over-polluted like some of the areas in the northeast, indicate that nitrogen nutrients from direct rainfall are significant. When you add the numbers from acid rain, you begin to see alarming totals that could transform our current problem of eutrophication into a true crisis.

While the potential inputs from acid rain are impressive from a quantitative perspective, assessment of what we know about the impacts is depressive. We currently have little knowledge as to what the short and/or long term biological responses to this important source of nitrogen loading are in our coastal waters. Potentially, impacts of acid rain (i.e., nitrogen enrichment) may range from subtle changes in phytoplankton community composition to accelerated eutrophication, potentially leading to long-term undesirable water quality degradation. This could include blooms of nuisance phytoplankton accompanied by localized anoxia events, loss of desirable phytoplankton production, and, even more devastating, detrimental food-chain alterations that could include losses of economically important fish and shellfish.

NEED FOR A RESEARCH AGENDA

Clearly, scientific attention should be focused on the short and long-term environmental impacts of nitrogen-enriched acid rain on coastal ocean water quality. I would urge that at the very least a national program should address the following issues:

1. Examine the relative importance of atmospheric (rainfall and dry deposition) sources of nutrients (especially nitrogen) in the nutrient budget of estuaries, sounds and coastal oceans. The importance of rainfall relative to land-derived nitrogen inputs should be examined in detail on spatial and temporal bases, especially in regard to annual nutrient budgets. Also, the relative importance of "internal" (in situ recycling) nitrogen regeneration vs. new nitrogen inputs as factors regulating primary production must be assessed.

2. Utilizing in situ bioassay techniques (which I have developed in my Sea Grant project), we should examine and evaluate DIRECT impacts of acid vs. non-acid rainfall on phytoplankton species composition and phytoplankton production characteristics. In particular, attention should be focused on the potential for nuisance phytoplankton growth under the influence of different precipitation sources. Both long-term (2 to 5 years) and short term (weeks to a year) impacts on the phytoplankton community should be examined.

3. Utilizing a multi-disciplinary, multi-media approach, we need to trace the fate of nitrogen derived from rainfall vs. nitrogen derived from land-borne sources in the coastal ocean. Our knowledge of fates such as storage in the sediments, vertical and horizontal transports, etc., of different nitrogen inputs is especially limited. Experiments in this area are particularly instrumental in determining to what extent inputs are transported and ultimately responsible for altering trophic and water quality conditions in the coastal ocean at locations other than the site of input. Stable isotope technology utilizing high sensitivity mass spectrometry is now available and will be useful in addressing this question.

4. We need to develop multi-media nutrient-loading/hydrological transport models capable of evaluating the relative importance of rainfall nitrogen inputs vs. land-borne sources and their fates. Construction and utilization of such models are particularly needed for water quality management purposes.

There are several entities available to provide mechanisms for the development of a research initiative on this important issue. The Sea Grant College Program is already poised to provide the framework, but additional funds are needed. The newly-authorized Strategic Research Initiative in the Sea Grant Act provides a particularly attractive vehicle if appropriations can be obtained to make it go. Other agencies also have the capability to launch the needed program, but I would caution you to make sure that the proper identification of the best researchers in the context of the proper questions is secured.

CONCLUSIONS

I have just hit the high points in this brief statement, but the following conclusions are relevant:

1. Acid rain appears to be a significant source of nitrogen into our already stressed estuaries and coastal oceans.

2. Experimental results have shown acid-rain derived nitrogen to stimulate phytoplankton growth in estuarine and coastal ocean habitats. Qualitative impacts/alterations on phytoplankton and higher-ranked consumers (food chains) are unknown at present.

3. Our knowledge of the relative impacts of nitrogen from acid rain is limited at best, and we desperately need fundamental information on the source, fate and impact of atmospheric nitrogen in the coastal ocean.

4. A focused research program is needed before it is too late to reverse the trend.

5. The National Sea Grant College Program is particularly well-suited to provide the multi-disciplinary research program needed for this issue, especially the strategic research program.

Thank you for this opportunity to share my concerns with you. You are to be commended for addressing this issue in a timely fashion. If I may be of assistance to you as you consider this complex situation, please call on me.

Senator KERRY. Thank you very much.
Dr. Driscoll.

STATEMENT OF DR. CHARLES T. DRISCOLL, PROFESSOR, SYRACUSE UNIVERSITY

Dr. DRISCOLL. Senator, I am a professor of engineering at Syracuse University. I have been asked to provide testimony on the recent Environmental Defense Fund report, "Polluted coastal waters: the role of acid rain." And in particular, I am to comment on the role of atmospheric nitrogen deposition by forests.

My professional expertise is in environmental chemistry and biology, and I have been studying the movement of chemical materials within both forests and aquatic systems for the past twelve years. I am the U.S. representative on an international panel of scientists currently summarizing the effects of atmospheric nitrogen on soil and surface waters both in Europe as well as North America. In addition, four years ago I was designated as a Presidential Young Investigator. My research associated with this award has been a study of effects of atmospheric nitrogen deposition on surface waters in the northeastern U.S. I have focused research on this issue because it's a challenging and important problem, and there have been few studies on environmental effects of nitrogen deposition in the U.S.

Atmospheric deposition of nitrogen is an important issue for three reasons: First of all, nitrogen contributes to the acidification of lakes and streams in the Northeastern United States; second, European researchers have suggested that it may be a factor contributing to forest decline; and third, now with the EDF report, as a nutrient nitrogen enrichment of coastal waters may cause oxygen depletion and associated water quality problems.

I have carefully reviewed the EDF report and find it to be a useful back of the envelope calculation of nitrogen sources to the Chesapeake Bay. However, I do not believe that some of the relatively strong conclusions of the report are warranted, given the very large uncertainty in these calculations. The results of this analysis are strongly dependent on the assumptions used, particularly the fate of atmospheric nitrogen on land.

The state of the science on this issue is adequately described within the EDF report, and I refer you to it on page 54, and I quote, "We then estimate how much nitrogen will run off each land type. We based our estimates on existing studies of nitrogen retention by land type. Such studies are limited both in number and in scope and generally do not examine watersheds as large and as complex as the Chesapeake Bay. Further studies should be done to improve our understanding of how nitrogen is cycled, especially by large watersheds."

To illustrate this uncertainty, I would show you some precipitation and streamwater information from a site used in the EDF report to determine watershed retention of nitrogen (Figure 1). This site is one of the most intensively studied watersheds in the world, the Hubbard Brook Experimental Forest in New Hampshire. My point is to illustrate that short-term records can be misleading and long-term study is required to determine real environmental trends. Chemical and biological transformations of nitrogen have been studied in air, water, vegetation and soil at this site for 25 years. The EDF report, however, only used the first 11 years of study (1963–74). If you focus on the early record (Figure 1; 1963–74) one could easily conclude that precipitation inputs of nitrogen increased due to increases in emissions of nitrogen oxides, causing an increase in streamwater nitrogen. However, examination of the total record shows this conclusion to be false. In fact there is no statistically significant trend in precipitation nitrogen or nitrate over the study period. In addition, since the mid-1970's stream nitrogen has actually declined and is currently strongly retained at Hubbard Brook.

Although the study of nitrogen has long been a focus of intensive research at Hubbard Brook, frankly we don't know the reason for these trends in stream nitrogen. Much of this uncertainty is due to the fact that the nitrogen cycle is very complicated and difficult to measure. Forests contain large amounts of nitrogen within trees and soil. In fact the annual nitrogen in precipitation is less than 0.1% of the total watershed nitrogen at Hubbard Brook, as in most forested areas. A simple calculation illustrates how sensitive the EDF calculations are to small disturbances of nitrogen in land. If just 1% of the forest nitrogen was released at Hubbard Brook, stream nitrogen would increase by a factor of 10 above current concentrations. Other problems include large uncertainty in important processes, such as inputs of dry deposition and nitrogen fixation, losses by denitrification, variations in hydrologic flowpaths as well as accumulation by soil and vegetation. These are either superficially considered, or worse ignored, in the EDF report.

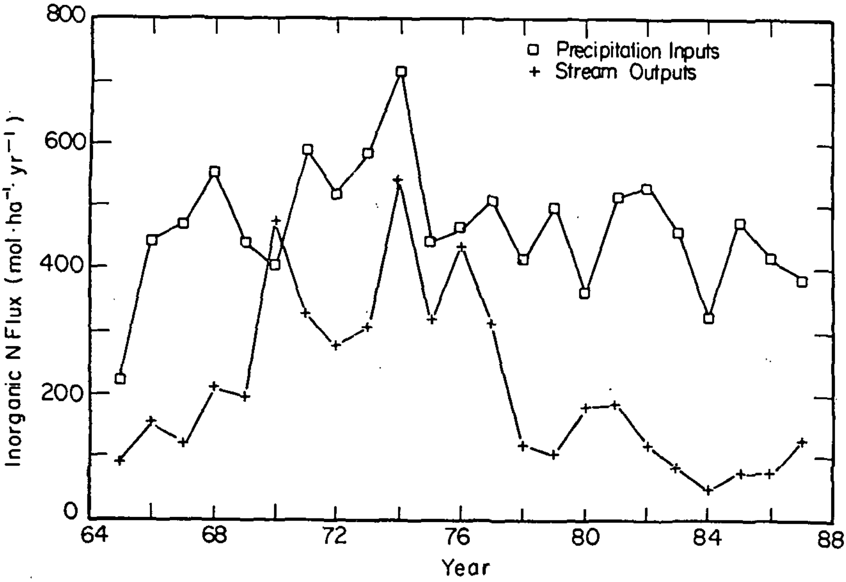

Figure 1. Precipitation loading and stream outflow of inorganic nitrogen (NH_4^+ + NO_3^-) at the Hubbard Brook Experimental Forest, NH

In summary, the EDF report should be viewed as exactly what it is, a grey literature report that has not been subject to rigorous scientific review. If this report had been released as initial assessment to stimulate interest or research by scientists, policymakers or agencies, then it would be a useful document. However, some of the conclusions in the document, as well as the depiction of the report by the popular press, go well beyond this, suggesting that the sky is falling.

Well, the sky may be indeed falling, but the EDF report does not have the hard data to prove it. There are large uncertainties and major simplifying assumptions used in this back of the envelope calculation.

Given these limitations, the EDF should conduct a detailed uncertainty analysis associated with the calculations. Such an analysis would illustrate the bounds of the problem and allow the reader to place the conclusions in proper perspective with scientific knowledge.

If there is a redeeming factor, it is that this report clearly calls to attention deficiencies in our national research program on environmental consequences of atmospheric deposition. First, as has been mentioned previously, the current focus is overwhelmingly on sulfur deposition, and little attention is being given to other pollutants such as nitrogen which we are addressing today. If some effort had been made previously to address the effects of nitrogen oxide emissions, then the information would be available to produce a more rigorous, scientifically defensible assessment on the role of atmospheric nitrogen to the Bay.

Second has been mentioned by other speakers. There is an acute need for commitment to long term monitoring and study of ecosystems. Through such a program information on the effects of pollutants and long term trends in ecosystem parameters would be available to address emerging environmental problems of regional, national and global significance.

Thank you.

Senator KERRY. Thank you very much, Dr. Driscoll. I appreciate that.

Dr. Taft.

STATEMENT OF JAY L. TAFT, DIRECTOR OF ADMINISTRATION, DEPARTMENT OF ORGANISMIC AND EVOLUTIONARY BIOLOGY, HARVARD UNIVERSITY

Dr. TAFT. Thank you, Senator Kerry, for this opportunity to discuss the role of nitrogen in coastal waters.

I am Jay Taft, and although I live and work in Massachusetts, I have spent most of my professional scientific life focused on Chesapeake Bay.

Various pathways have been discussed this morning through which nitrogen gets into the Chesapeake Bay, one of the largest and most significant estuaries in the nation, and this morning we have heard some of the uncertainties regarding those routes and the estimates of the amount of atmospherically deposited nitrogen that is reaching the estuary.

I would like to just spend a few minutes this morning giving my view on two questions which I do not think we have really touched on yet: How does nitrogen leave the Chesapeake Bay once it is there; and secondly, when and where is nitrogen derived from atmospheric deposition likely to have a significant effect on Chesapeake Bay? Part of that problem is that the signal from other sources has been so large that whatever estimate we accept for atmospheric input has been difficult to detect in the main portion of Chesapeake Bay.

The first question is, how does nitrogen leave the Bay? Well, first, it can flow out of the mouth to the coastal ocean.

Senator KERRY. I missed that line. What type of nitrogen has been difficult to detect in Chesapeake Bay.

Dr. TAFT. The effect of atmospherically derived nitrogen on the biota of Chesapeake Bay has been difficult to detect, and it has been difficult to detect because the signal from other sources has been so large.

So it has been hard to sort out the atmospheric source in the main portion of the Bay.

How does nitrogen leave? First, it can flow out the mouth to the coastal ocean. The data on how much is leaving by this route are sparse. But it appears that some leaves during the high runoff period in the springtime when a large load of nitrate is delivered to the system. At other times during the year when runoff is much lower, the primary form of nitrogen leaving the Bay is organic, either as particulate phytoplankton or as dissolved organic material resulting from the death and decay of phytoplankton.

Secondly, nitrogen can be buried in the sediments, and indeed, the sediments are nitrogen enriched and themselves become an additional nitrogen source during the summertime in particular when nitrogen, in the form of ammonium, is released from the sediments in large quantity to the overlying water.

Thirdly, it can be converted to gaseous nitrogen and re-enter the atmosphere. Measurements in a few locations suggest that up to 20 percent of the nitrogen available to this process in the main portion of Chesapeake Bay can leave via the atmospheric route during cool weather, and up to 50 percent may leave the margins of the system as nitrogen gas back into the environment.

This is an area which is now under investigation. The data that we have are sparse, and it is very difficult to extrapolate from a few data points to the whole system. The current state and EPA funded program is emphasizing sediment processes and these denitrification processes over the next year and hopefully we will have a better sense of the magnitude of this particular route back into the atmosphere about a year from now.

One advantage of this route is that there seems to be a positive feedback mechanism. The anoxia that occurs in the Bay now damps and stops that process so that during the summer, denitrification does not take place. It only operates in the cooler seasons when the system is well oxygenated.

If we reach a point in the Bay's recovery that oxygen is present in the deep water during a larger fraction of the year, the removal processes may operate for a larger fraction of the year and thereby speed up the recovery of the system. So there is a positive feedback, in a sense, as we reduce nitrogen and other nutrient inputs and reduce the anoxia problem that we have seen in the Bay.

Thirdly, nitrogen may leave in migrating fish and organisms that are harvested commercially, fish, shellfish and crabs, but compared to what is in the system, that fraction is relatively small.

Even with these departure routes, much of the nitrogen entering the system stays in it. By the nature of the system itself, as a trap for nutrients, enough remains to cause the stresses that we see manifested as changes in the biota, such as the submerged aquatic vegetation which has been lost for most of the upper Bay, and the anoxia problem that we are all well aware of.

Secondly, given the problem in detecting the signal, when and where is nitrogen derived from atmospheric deposition likely to be significant in Chesapeake Bay, where are the possibilities for seeing such a signal under the current conditions? Precipitation which is held in the snowpack on the watershed of the Bay during the wintertime has about one-fifth to one-third the nitrate concentration that that same material has when it melts and reaches Chesapeake Bay. So by a very simple estimate, if we ignore any other processes except some additions which are caused by groundwater and other sources, about one-fifth to one-third of the nitrogen, nitrate nitrogen, coming into the Bay in the springtime may in fact have accumulated on the watershed during the winter.

This nitrogen contributes to the spring accumulation and growth of phytoplankton in the system. That growth ultimately ends up as a demand on the oxygen in the deep water of the Bay a little bit later. So there is a lag time.

Secondly, there is so much nitrogen delivered with the spring runoff that it all cannot be used, and in fact, some fraction of it is flushed out of the estuary into the coastal ocean. A rough estimate that I made some years ago is that about 27 percent, in one brief period where I made some measurements, found its way from the head of the estuary all the way out to the coastal ocean without being taken up by phytoplankton. That is in part because there is so much nitrogen, and the system becomes phosphorous limited, and also because under these conditions there is a lot of ammonium around, and the phytoplankton prefer to take up the ammonium when it is there and let the nitrate go by.

So there is some loss to the system during this time.

Secondly, atmospheric deposition directly on the Bay may be most significant in the southern half of the Bay during July and August when we believe that portion of the system is nitrogen limited. Flow is very low from the Virginia rivers and also from the Susquehanna, so that direct deposition of nitrogen on the surface may have some of the effects that Dr. Paerl has described for other estuaries in North Carolina.

I am not aware that we have made any direct measurements in this part of the Bay demonstrating that nitrogen stimulates growth, but I would suggest that an hypothesis of that nature could be tested in the way that Dr. Paerl has made measurements in North Carolina.

Thirdly, atmospheric deposition of nitrogen may be significant along margins of the estuarine system such as the Rhode River where the Smithsonian Institution has been making measurements for 15 years or so. These areas may not receive direct river runoff from major rivers and may not receive a great deal of upland runoff. So the direct atmospheric deposition of nitrogen may be important in those areas as well.

Again, I would like to thank you for this opportunity to discuss the problem and would welcome any questions you may have.

[The statement follows:]

STATEMENT OF JAY L. TAFT, DIRECTOR OF ADMINISTRATION, DEPARTMENT OF ORGANISMIC AND EVOLUTIONARY BIOLOGY, HARVARD UNIVERSITY

Thank you, Senator Kerry, for the opportunity to address the Committee on Commerce, Science, and Transportation and the National Ocean Policy Study. My name is Jay L. Taft, and I am Director of Administration for the Department of Organismic and Evolutionary Biology at Harvard University. For more than a decade I engaged in a research program, based at the Johns Hopkins University, on the dynamics of nutrients and natural plankton assemblages in the Chesapeake Bay estuary and the adjacent coastal ocean. I remain actively involved in the Chesapeake Bay in an advisory capacity, recently with the National Research Council and currently with the U. S. Environmental Protection Agency.

I would like to use this opportunity to review for your committee some of the characteristics of the Chesapeake Bay, emphasizing the role of nitrogen in the dynamics of this uniquely productive estuary. Increased population, changes in land use, and even phosphorus removal from waste-water have contributed to increased nitrogen transport to Chesapeake Bay during the last several decades, causing stress to the ecosystem. Atmospheric deposition, one source for nitrogen to the estuary, becomes increasingly important as efforts to reduce other inputs gain effectivness. Although I focus a specific coastal system, many of the processes are common to other estuaries of various types.

Characteristics of Chesapeake Bay

The Chesapeake Bay estuary is a system of large and small tributaries in which fresh water from the land meets and mixes with salt water from the ocean. This yields an aquatic environment in which salinity increases seaward and vertically with depth. The water circulation pattern in these 'partially mixed' estuaries differs from riverine circulation because, in addition to the seaward flowing surface layer typical of rivers, there is a strong landward flow in the deep layer. The deep landward flow transports particles, such as sediments and organisms, and dissolved materials upstream. This mechanism has lead to the characterization of these estuaries as traps for nutrients and sediments.

Nitrogen is a major nutrient for plant growth in the estuary. Other major nutrients are phosphorus, carbon and, for certain plants, silicon. Once incorporated into the organic matrix of plants, these nutrients are available to successively diverse groups of animals and other heterotrophic organisms which cannot synthesize organic matter from purely inorganic nutrients. The plants, most of which are single-celled phytoplankton, take up the major nutrients in proportion to their internal needs for each nutrient. Healthy phytoplankton have a characteristic ratio for the major nutrients in their cells which is approximately 106 atoms of carbon to 16 atoms of nitrogen to 1 atom of phosphorus. However, the estuary does not usually contain the major nutrients in exactly the optimum ratios for the phytoplankton. Most often, either nitrogen or phosphorus is out of balance with the phytoplankton needs, and thus limits the standing crop of phytoplankton which can be produced. Hence, the estuary may be described as nitrogen limited or phosphorus limited at various times and locations. One control technique, employed by environmental managers in aquatic systems stressed by too much organic material, is to identify the limiting nutrient and to attempt to further reduce its availability, thereby reducing the standing crop of phytoplankton and the associated stresses.

Nitrogen Dynamics

River discharge during the late winter and early spring is the primary source of inorganic nitrogen for the Chesapeake Bay. Flows reach the annual peak for water volume and for transport of suspended and dissolved materials. The inorganic nitrogen load delivered with this 'spring freshet' from the Susquehanna River is traceable for 300 kilometers to the bay mouth. One estimate, made for a brief period during May 1975, suggested that an amount approximating 27% of the nitrogen delivered as nitrate by the Susquehanna River left the bay mouth as nitrate. More recent studies focused on the interactions between the Chesapeake Bay and the adjacent ocean support the conclusion that some inorganic nitrogen passes through the bay to the ocean during the high flow period. However, in other seasons when river flow is much less, very little inorganic nitrogen leaves the bay mouth.

Four forms of inorganic nitrogen are typically found in the estuary: Ammonium, nitrite, nitrate and nitrogen gas. The first three occur as ions which may be taken up by phytoplankton and incorporated into cellular constituents. Natural assemblages of phytoplankton take up inorganic nitrogen in the preferential order of ammonium, nitrite and nitrate when presented with significant concentrations of two or more forms.

In the estuary there are also a suite of organisms, primarily bacteria, which derive energy from converting nitrogen among its inorganic forms. Nitrification is the biological oxidation of ammonium to nitrite and then to nitrate. Denitrification, on the other hand, is the biological reduction of nitrate or nitrite to either nitrous oxide gas or free nitrogen gas. Denitrification occurs in oxygen depleted environments.

Having entered the living ecological web, some of the organic nitrogen may be returned to the water as inorganic excretions from animals, and through the activity of decomposer organisms. The remainder exists in the organic form for longer periods either as dead particulate matter or as dissolved organic matter. Some of the particulate organic nitrogen sinks to the bottom where it is consumed by organisms inhabiting the sediments or is buried. The dissolved organic nitrogen may be further remineralized to inorganic forms by planktonic bacteria, and some resists degradation to ultimately be transported from the estuary by the regular water circulation.

Indications of Stress

The processes I have briefly described interact to make Chesapeake Bay one of the most productive estuaries in the world. One consequence of high organic production in the Chesapeake Bay is a similarly high rate organic degradation, a process requiring oxygen. The circulation pattern which tends to keep material in the estuary also tends to inhibit exchange between the deep layer and the surface layer. Oxygen transfer from the atmosphere via the surface layer to the deep layer is inhibited and the deep layer becomes oxygen depleted. Hence, one of the stresses in Chesapeake Bay is oxygen deprivation in the deep layer, particularly during summer. This natural phenomenon, which has probably occurred periodically for much of the Bay's life, has in recent times expanded to cover more of the Bay for most of the summer.

Oxygen depletion is a direct result of the nutrients entering the Bay and being retained in it for long periods, relative to systems with unidirectional water flow. The historical nutrient data base for the Bay reveals a trend of increasing nitrogen which reflects man's activities in the watershed.

Bay-Atmosphere Interactions

Although the estuary retains a significant fraction of dissolved and particulate nutrients, gasses produced in the system equilibrate with the atmosphere. Denitrification processes convert dissolved nitrogen to gaseous forms which escape from the estuarine nutrient cycle. Denitrification occurs primarily in the sediments, but at times may also operate in the water column. Denitrification measurements from a few locations in the Chesapeake Bay indicate that a significant fraction of the nitrogen available to the process may be converted to a gas which escapes from the estuary. However, much more research is needed to describe the geographical and temporal extent of denitrification and its relation to other aspects of nitrogen dynamics.

It is not new information that the transport system for nitrogen in coastal waters includes the atmosphere. For example, since 1973 Smithsonian Institution scientists have recorded the nitrogen content and acidity of rain falling on the Rhode River watershed, a subestuary on the Bay's western shore. Among other literature cited in the Environmental Defense Fund report, **Polluted Coastal Waters: The Role of Acid Rain**, is the U. S. Environmental Protection Agency report issued in 1982 entitled, **Chesapeake Bay Program Technical Studies: A Synthesis**. Seasonal estimates in the EPA report for the fraction of organic and inorganic nitrogen delivered by direct deposition on the estuary ranged from 6% in fall and winter to 20% in summer, with an annual average of 13%. Drawing information from another EPA report, the EDF estimates 9% as the annual fraction of nitrate and ammonium nitrogen contributed from direct deposition.

What is new in the EDF report is the emphasis on the role of anthropogenic nitrogen inputs to the atmosphere which contribute to acid rain and to nutrient enrichment of coastal waters. The EPA report focused on other aspects of the nitrogen transport system, within the drainage basin, delivering nutrients to the estuary. The atmospheric route obviously extends well beyond the basin, both up- and downwind. The chemistry and the transport of nitrogen in the atmosphere are receiving attention in the scientific literature. For example, the last two issues of one journal published by the American Geophysical Union contained 16 articles on the subject of atmospheric processes extending eastward from North America across the Atlantic Ocean, 5 of which specifically address nitrogen.

Atmospheric scientists are looking into the natural processes which transform and transport nitrogen in the atmosphere, while scientists concerned with other segments of the environment work to improve our understanding of the exchanges between ecosystems on the Earth's surface, and between the surface and the atmosphere. There are quantitative estimates for some processes, but many questions, such as these, remain: What are the natural production and degradation rates for nitrate and ammonium in the atmosphere? What physical and chemical parameters influence the rates? What fraction of the nitrogen deposited in the Chesapeake Bay watershed is natural and what fraction anthropogenic? How much nitrogen is released, through man's activities and through natural denitrification, by the Chesapeake Bay watershed to the atmosphere? How much nitrogen leaves the Bay via the mouth? How much nitrogen is effectively buried for the long term in sediments? How variable are these processes in time and space?

Current Scientific Activities

The efforts to answer some of these questions for the Chesapeake Bay can be grouped in three general categories: Regular environmental monitoring to track trends and assess variability in time and space; basic research into the physical, chemical and biological processes occuring in the open water and along the margins of the system; development and use of new tools in the form of sophisticated mathematical models for analyzing the state of our knowledge about the estuary, and projecting probable effects of management actions or inactions.

The states in the watershed and several federal agencies, including the EPA, the US Geological Survey, the US Fish and Wildlife Service, are engaged in a cooperative effort to monitor the water quality of the Bay and its tributaries. The states and the federal government, through the National Science Foundation, Maryland Sea Grant Program and other agencies, support basic research into the estuarine processes described here as well as others I have not touched upon. The states and the EPA have already produced the first mathematical model for the entire Bay to assist managers evaluate the environmental consequences of various control scenarios. Moreover, this collaboration has led to a partnership with the Army Corps of Engineers to produce a second, more sophisticated mathematical model which will permit simulations of the Bay during all seasons and in greater detail than the existing model.

Conclusions

1. Nitrogen inputs resulting from human activity, when accompanied by other factors such as phosphorus inputs and water stratification, have stressed the Chesapeake Bay estuarine system.

2. Although the contribution of atmospheric nitrogen deposition to estuarine productivity was evident a decade ago, management emphasis was placed on other nitrogen sources in the Chesapeake Bay watershed.

3. As other nitrogen inputs to the estuary become better controlled, the contribution from atmospheric deposition will assume increased importance.

4. There are both formal organizations and informal associations in place in the Chesapeake Bay region through which to focus attention on the issues of atmospheric deposition.

5. Because atmospheric processes operate on hemispheric, if not global, scales, there is a continuing need for scientists, policy makers and managers to address the issues of atmospheric inputs, transport and deposition on comparable scales.

Senator KERRY. I want to thank all three of you for bringing a very important expertise to this, and I want to sort out a little bit if I can and try to simplify some of the conclusions here.

Dr. Taft, let me sort of pick up where you left off.

The EDF study concludes that atmospheric nitrate is currently the second largest source for nitrate input to the Bay and may soon be the largest.

Do you believe that information currently available supports that conclusion?

Dr. TAFT. The problem I have is the same problem that my colleague at the other end of the table has, is that I do not know of anyone who can track a molecule of nitrate from the watershed through various land uses and into Chesapeake Bay. I believe that acid rain is a problem just based on the measurements in the rainfall and some simple calculations that we can make for various portions of the estuary.

Senator KERRY. Is there anything else that shows a larger source?

Dr. TAFT. Currently the agricultural runoff is a major problem.

Senator KERRY. That is number one, right?

Dr. TAFT. Yes.

Senator KERRY. But they acknowledge that.

Dr. TAFT. And sewage——

Senator KERRY. And they are saying this is the second largest. Is there anything else that could be the second largest?

Dr. TAFT. Sewage effluent potentially can be a very large input. The lag time for that, getting from the pipe down into the estuary, is hard to estimate, so that we cannot really do those calculations yet. One of the purposes of the EPA model is to help us do that.

What we do know is that if only phosphorous is taken out of the sewage effluent, you expedite the process of getting nitrogen downstream because there is less phytoplankton growth and sedimentation, so that the material does not sort of pogo stick its way down the rivers into the estuary. It comes right on down. And we have seen that in the Potomac River.

Senator KERRY. So you are saying you do not know whether or not it is the second largest.

Dr. TAFT. No, I could not assert that it (atmospheric deposition) is the second largest.

Senator KERRY. Is there anybody else here who can agree or disagree?

No, okay.

Do you disagree with the percentages that have been asserted in the report, leaving aside whether it is the second largest? I mean, do you think the range of percentages is reasonable?

Dr. TAFT. Based on my own measurements in snowpack around the estuary, they seem reasonable. What I cannot address is how much of that nitrogen in precipitation that falls during the growing season actually reaches the Chesapeake Bay, and I point out that the concentrations triple from the time the snow melts until the water reaches the estuary, and that is due to what has been picked up, the accumulation effects you mentioned, and what has been contributed by ground water and applications of nitrogen to the soil that gets into the ground water.

I think their numbers for deposition are probably correct. I cannot assert how much of that deposited material is getting into the Bay, having been filtered through the watershed.

Senator KERRY. Do you agree with the conclusion that much of the deterioration of the Chesapeake Bay can be attributed to increased nitrogen loading?

Dr. TAFT. Yes, I do agree with that.

Senator KERRY. And can you state to what extent, allowing for a very conservative runoff estimate, that atmospheric deposition would contribute to that nitrogen loading? Do you feel confident in your ability to do that?

Dr. TAFT. No, I cannot because the problem—the question is clouded. The answer to the question is clouded because when that nitrogen reaches the estuary, there are a number of possibilities. The phytoplankton could ignore it because there is abundant ammonium around and the nitrate could pass right on out. The nitrate could pass into the sediment, be denitrified and leave the system as a gas and have no effect on the system.

So until we have tools to adequately sort out those routes and processes in the system, I could not track for you a molecule of nitrate.

I believe atmospheric deposition is important. I believe its importance will become more evident as we make reductions in other nutrient loads such as the nutrient load due to non-point source runoff. But I cannot point to a specific effect. I am suggesting some places where there might be some, but I cannot hold up data for you and assert that there are.

Senator KERRY. Is it possible to isolate that with a fair degree of certainty in a short period of time?

Dr. TAFT. I think it could be done in a couple of areas, and certainly the work that has been done by the Smithsonian in the Rhode River is the first place to look. They have been concerned about it since 1973 or so, and there are good data there. And I think some judicious experiments in the lower half of Chesapeake Bay during July and August would help us answer those questions.

Senator KERRY. Are there any other areas of research that would be valuable in contributing to this?

Dr. TAFT. There are, and there are a lot going on right now in the Chesapeake, both through the auspices of the Chesapeake Bay program. Established and fostered by the Chesapeake Bay Agreement that has been discussed, and there are also basic other programs. Sea Grant is operating in the Bay, the National Science Foundation is funding basic process work in the Bay, and the scientists are all communicating with one another.

So I think that yes, I think that we will learn more about the answers to the questions you are asking me in the next year or so.

Senator KERRY. Dr. Driscoll, are you asserting in your criticism of the report that it is unreasonable to assume that 20 percent of the nitrogen that falls in the forest would end up in the rivers and streams?

Dr. DRISCOLL. I am not saying it is an unreasonable assumption. What I am saying is that we really have very little information to come up with that 20 percent.

I have been involved, as I indicated, in a compilation of information from watershed studies around the U.S., and these are a total of 50 sites. They represent small watershed studies. The values of nitrogen retention vary from 50 percent down to virtually zero. There is quite a wide range within these systems. And frankly, we do not have a good understanding of what is controlling the nitrogen leaching from these systems.

You have to realize that there is a huge pool of nitrogen within these forests, and the amount coming in in rainwater in any one year represents a relatively small fraction to the total pool.

Senator KERRY. It depends on the forest, right?

Dr. DRISCOLL. It depends on the forest, it depends on the hydrology, it depends on the state of growth of the forest, the soils, a variety of factors.

If I might add, to give you some idea of this, in my written testimony I provided some information on input-output budgets for a site, a very well studied site, a small watershed in New Hampshire which has been studied for 25 years, and if you can look on this plot you can see the input is relatively constant throughout the period of time, no statistically significant difference. However, if you look at the output, which is the lower part, you can see that it increases to about the early seventies, and actually, outputs at this point in time approached inputs, close to 100 percent loss.

You see, however, in more recent years the pattern is reversed, and now the system is strongly retaining nitrogen.

We have been studying the nitrogen cycle at this site for 25 years, and frankly, we do not have a good idea of why we have that blip in nitrogen loss. And I think really this points out the need for better watershed level studies to try to nail down the reason for that and nail down these retention factors.

Senator KERRY. For a watershed as significantly forested and as large as the Chesapeake Bay area, can you arrive at a most conservative estimate as to the runoff that gives you a pretty good indication of what is happening?

Dr. DRISCOLL. Of runoff, sir?

Senator KERRY. Yes.

Dr. DRISCOLL. Well, it varies depending on type of land use, but I could see where——

Senator KERRY. I am not forcing. I am just curious, can one come to a safe, scientific assessment, a conservative one, as to a sort of minimal runoff level for something like the Chesapeake Bay area? Is it possible to do that, obviously not being totally accurate, but just the conservative, low end estimate.

Dr. DRISCOLL. I think those numbers could be tightened up quite a bit with the existing information. I also think that there could be some relatively straightforward, simple experiments that could be done to provide much better information.

For example, just simply manipulating a system, as my colleague at the end of the table indicated, a major source of nitrogen is in snowpack, you could simply manipulate a small catchment, enrich the nitrogen like you were simulating additional loading, and monitor to what extent that ran off. Plus you could use tracers to track, as he suggested, the molecules of nitrogen through the system and see to what extent it was lost or retained within the system.

So I think a modest research effort could really tighten up these numbers.

Senator KERRY. In short order.

Dr. DRISCOLL. In short order.

Senator KERRY. Would that be valuable?

Dr. DRISCOLL. I think it would be valuable, yes.

Senator KERRY. Describe for me how you view the impact of this report. What is the significance of it from the perspective of this dialogue.

Dr. DRISCOLL. Well, I think the strength of the report is that it calls to the attention of scientists and people in general that nitrogen is a problem, and nitrogen is potentially a problem not only with respect to the Bay, as is discussed here, but also it has been discussed in the acidification of lakes and streams. It is also an area of major focus in Europe.

The Europeans are frankly very concerned about nitrogen. There are major research intiatives on nitrogen in Europe. So I think it is worth some attention.

I am not saying that there is definitely a problem, but I think it warrants some attention.

Senator KERRY. You discussed the need for a long term monitoring study of the ecosystem so we can better understand that. How would you design that kind of monitoring system?

Dr. DRISCOLL. I think what it would require is well-defined systems, preferably systems that have a track record of research and monitoring. I think it would require steady funding for a long period of time, and monitoring a variety of chemical parameters, coupled with basic research on the processes by which these materials move through.

I would argue that this would be a cost effective program. It would allow us to address problems like we are discussing here today, as well as a variety of emerging problems that you know we are going to be discussing in the future.

So I think it would be money in the bank.

Senator KERRY. Dr. Paerl, do you agree with the assessment that acid rain may become the single most important source of nitrogen in the marine ecosystems?

Dr. PAERL. I think that depends on the system receiving this nitrogen source. If we are talking about Chesapeake Bay, quantitatively it may never exceed other sources, such as point and nonpoint source inputs.

If we are looking at our coastal oceans—and there are some differences here between the North Carolina coastline, for example, and Chesapeake Bay, in that in North Carolina much of the nitrogen is stripped out of estuaries prior to discharge into the coastal oceans. As a result, we have very little nitrogen coming into our coastal oceans.

Most of the nitrogen is recycled (as opposed to new inputs) within these systems. Under those conditions, nitrogen deposition from the atmosphere may be the most important source, particularly if we are looking at a localized (high rainfall, particulated, high annual acid rain inputs) situations.

So as usual, that question needs to be answered with an "it depends," on what kind of system we are talking about. But I think there are examples where on a budgetary basis acid rain could possibly be the most important new nitrogen input, yes.

Senator KERRY. Have you been able to draw any conclusions about the contribution of nitrogen deposition to the red tide problem?

Dr. PAERL. No, the red tide problem is something that caught us by surprise in North Carolina, because it is the first time that a toxic bloom of these dinoflagellate organisms has ever been documented in these waters. Now, that is reason for concern, and certainly one is tempted to think that enhanced nutrient loading from any source, including possibly atmospheric sources, may play an important role.

But we have not really addressed this problem with scientific studies yet. And it really requires, I think, an interdisciplinary effort to combine both knowledge of processes in the watershed, such as my colleagues possess here, as well as biological knowledge as to how these nutrients are translated into what we call desirable versus undesirable algae in our coastal oceans.

I might add that to a certain amount of fertility (in the form of phytoplanleton production) is desireable in order to support the food chain. I do not think any of us are saying that there should not be any new nitrogen coming in at all. The important point here is that there is a fine line between desirable fertility and excessive fertility in the form of nuisance algae growth, such as red tides or blue-green algal blooms, in these systems.

And then of course, we must look at higher levels of. What are the food chain into what the responses of consumers of these organisms (nuisance algae), how are things changing on the invertebrate, and ultimately on the fisheries level.

Senator KERRY. What have you observed in terms of the impact in North Carolina of the algae blooms that you have witnessed and studied? What has been their impact?

Dr. PAERL. We know that in some cases there have been subtle changes in the food chain, where one type of zooplankton might be replaced by another, both of which make fairly good food sources for higher ranked organisms. However, in some cases such as blue-green algal blooms, there have been serious changes as far as the food chains making use of phytoplaleton are concerned.

What happens under nuisance algal bloom conditions—and I think there is good coupling between enhanced nutrient loading, by the way, and the incidences of such blooms—is that bloom organisms are often difficult to eat because they are either awkward in shape, they live colonially or they are toxic.

These are at least three reasons why a blue-green algae, for example, would be rejected as a food source by a higher ranked organism. This means that such algae are basically a dead end as far effective food transfer in such a food chain is concerned.

Coloniality in these organisms makes them very difficult to eat—in human terms it is like trying to eat a pizza without cutting it up into pieces while your hands tied behind your back. It becomes a structural problem in terms of how one consumes these types of organisms.

We also observe toxicity problems very often associated with these organisms. In concert, such problems translate into problems and changes higher up the food chain.

Senator KERRY. Do you believe that acid rain contributes as part of that threat, in estuaries like the Chesapeake or in other waters?

Dr. PAERL. Well, certainly in a system like the Chesapeake, which is already affected by enhanced nutrient loading, it is aggravating the situation further. It is basically adding more nitrogen to an already nitrogen-stressed system.

Senator KERRY. Let me just ask a quick question of the others. Does anybody disagree with that basic assessment? While you may not know the level, you may not know the exact relationship, does anybody disagree with that assessment?

No.

Sorry to interrupt.

Dr. PAERL. We have numerous estuarine and coastal systems that are already aggravated by nutrient loading. Additional nutrient (specifically nitrogen) inputs would have a tendency to accelerate the rate of eutrophication.

We also have waters that are not experiencing that type of advanced eutrophication yet. And I would like to emphasize that we should look at this problem from a twofold perspective.

We should look at a system which is already aggravated and examine additional impacts. Such a system is Chesapeake Bay. But there are many coastal habitats up and down the East Coast, as I mentioned previously at least as far south as North Carolina, that have very subtle productivity and algae species composition changes going on in them. Such systems have not gone anoxic yet. We do not have food chain problems yet. But I think we should examine this problem on a comparative basis to see how fast things are changing in relatively unperturbed, or what we think are unperturbed systems, as well as a system which has a history of eutrophication already going on in it.

One major reason for taking such a comparative approach, of course, is that perhaps we can look at the symptomology at a fairly early stage in some of the more pristine habitats.

Senator KERRY. Is it possible, going back to your open ocean versus estuary observation——

Dr. PAERL. If I could correct you, we are discussing coastal oceans. Open oceans pose a different set of questions.

Senator KERRY. I meant coastal.

To what depth or to what configuration, then, do coastal oceans differ from open oceans?

Dr. PAERL. Well, when one considers the nitrogen inputs versus the volume of the receiving body of water, you get a great deal more dilution, of course, in an deep (greater than 50–100 meters) open ocean system than in a shallow coastal ocean system (such as the Albermarle Pamlico Sound System) in North Carolina.

Senator KERRY. So the key measurement would be the dilution factor, not necessarily——

Dr. PAERL. It is a very important number along with loading, because the organisms see concentrations. If the concentration changes following loading are very subtle, they are not likely to have a measurable impacts.

And so in the coastal ocean environments, that is the shallow coastal waters—and we have lots of those in the middle Atlantic states—we have done some calculations that indicate that acid rain-derived nitrogen is a measurable input as far as the total amount of nitrogen present in those systems.

When one gets off the shelf region, of course, then it becomes a very different question, and it is more a question of what is happening in the surface waters of those particular regions where the nitrogen loading would be most noticeable.

Senator KERRY. Let me just say to all of you that your full testimony will be made part of the record. I am going to leave the record open, as I said earlier, we may want to submit some additional questions to you for clarification purposes and just to follow up.

But I really want to express my appreciation to all of you for taking the time to join us and add to this new dialogue, one obviously I think that is going to prove itself to be very important.

Let me just say also that last year Senator Hollings and I included a new research program in the Sea Grant reauthorization bill, and we established the strategic research program. It was our intention that that program would look at national ocean concerns.

And this week we are going to be meeting to allocate the first funds for that program. It is my intention to talk to both the Secretary of Commerce as well as the Under Secretary of NOAA to discuss the possibility of moving in this particular area of research as a means of appropriate utilization of those funds.

And I think it would be good if we could begin to really focus on the issues that you have raised. Obviously, there are some questions. Today's hearing has clarified some of those questions.

I think everybody, however, is in agreement that the EDF report is an important contribution to raising people's consciousness on this question of nitrogen loading and its impact. In the past, we had focused only on the SO_2 side of things. This report is getting us to recognize larger relationships and larger interrelationships here.

So I think today has been very valuable in that, though I cannot underscore enough how much this Senator at least hopes that it is not going to lead to another decade of studying and finagling over whether it is 15 percent or 20 percent.

We have got to make some basic judgments here and I think we have got to make them pretty quickly. And I think there are only so many options as to where we are going to begin to move to make reductions on things that have an obvious impact of one kind or another.

And I hope that you folks can join with us in trying to contribute to that constructively. And I think your suggestions about how we can narrow some of these numbers and other things are constructive, and I hope we can move on that.

We do have one more panel, with respect to marine sanctuaries. So I would like to move to that if I can, and thank you all for joining us.

Could I ask Mr. Uravitch to come forward.

Mr. Uravitch, thank you for your patience. It is by no means an indication that we consider this reauthorization any less important, I am very appreciative.

Do you have an opening statement that you want to make?

STATEMENT OF JOSEPH A. URAVITCH, CHIEF, MARINE AND ESTUARINE MANAGEMENT DIVISION, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE

Mr. URAVITCH. No, sir. Just what I will do is submit my written testimony for the record and then summarize it for you, if that is appropriate.

Senator KERRY. That is terrific, and we will reprint your testimony in full. And I appreciate your summary.

Mr. URAVITCH. Thank you.

My name is Joseph Uravitch and I am the Chief of the Marine and Estuarine Management Division of NOAA. The last time we appeared for reauthorization was 1984. Since that time, we have designated a seventh marine sanctuary at Fagatele Bay in American Samoa, and we are in the process of designating three additional sanctuaries: Cordell Bank in California, Flower Garden Banks in the Gulf of Mexico, and Norfolk Canyon.

Regarding authorization levels, the administration supports the reauthorization of Title III at a level of $2.325 million for fiscal year 1989 and such sums as necessary for fiscal year 1990.

We have submitted a draft legislative proposal that would reauthorize Title III at these levels, and it also makes some technical amendments regarding enforcement which I will not go into in detail.

Regarding future designations, we have three sites under active consideration. We are designating new sanctuaries at a pace which we believe will allow us to integrate these sites into a well-managed national marine sanctuary system currently at the rate of approximately one per year in 1988, 1989, and 1990, starting on-site operations in the following year.

The first of these will be Cordell Bank in Federal waters off Point Reyes, California, which should be designated by the end of this year. We are now preparing the final EIS in response to a large number of comments, and we should see that out in the near future.

We plan to designate Flower Garden Banks in the Gulf of Mexico in 1989. We submitted our section 7 consultations to the National Marine Fisheries Service and to the Department of the Interior last week, and we anticipate our draft EIS will be available for public comment probably late July.

We have already held a scoping meeting for the Norfolk Canyon national marine sanctuary proposal, which is 60 nautical miles off the Virginia coast. Designation is anticipated either early in 1990 or late 1989. We just applied a new staff member to that project, so we are trying to pick up some speed on that particular sanctuary.

Regarding the designations beyond this point, we do intend to move forward with additional designations. However, we would first like to review our site evaluation list from which those candidates are selected. That list has been in existence since 1983, and after five years we are supposed to review that list.

We do intend to do that. We have had considerable comment on boundary changes, sites not on the list, et cetera. So we think that that is appropriate, that we solicit some public comment before we just pick additional sites directly from that list.

Based solely on a geographic basis, what we see are no sites currently in the Northeast, Northwest, Great Lakes, or Caribbean waters. So on that basis, those are some of the areas that we would be looking for in terms of priority.

In addition, we are looking at additional historic and cultural resource sites to complement our existing U.S.S. *Monitor* sanctuary and we are in the process of putting together a separate site evaluation list for historical and cultural resources. We intend to have that activity completed within the next six to nine months.

Other things we have been involved in for the past four years have been primarily improvement of existing sanctuaries, since we did have four come on line in the early 1980's.

Specifically, first we have almost completed standardization of penalty schedules for violation of sanctuary regulations. We have hired on-site staff for our sanctuaries in both the East and West, and have provided resources for them to manage, including enforcement tools like ships, equipment and on-site facilities.

Second, we are currently reviewing our operational procedures to try and standardize these activities throughout the country. The system was built somewhat on a site-by-site basis, and we are in the process now of trying to make some standard activities for the whole system.

Specific activities we are involved in are developing a research and education program comparable to that which we have under our National Estuarine Reserve Research System program, which we also administer. We are reviewing the site specific regulations for each of these sanctuaries to assure essentially that we handle the same kinds of issues in a comparable manner throughout the country.

Third, we are in the process of developing an on-site sanctuary manager's manual so we can put people on site so we operate on a standard basis throughout the country.

Fourth, we are reviewing the resources and regulations of all our sanctuaries to see if we can protect existing historical and cultural resources which may be in there, but were not part of the original reason for designation of those sites.

There are two additional issues where the administration has a position that have arisen since we began reviewing this particular Act. One relates to the establishment of an emergency response and damage assessment fund, and we do strongly support the purpose of this particular fund, in that it does permit the government, in the event of injury, destruction or loss to sanctuary resources, to recover the value of that damage to the resources from responsible parties.

What we would oppose is using recovered funds beyond the amount for that particular recovery purpose for normal sanctuary management purposes, since that would violate and bypass the normal authorization and appropriation process.

The other area where we see a need for some change is in the need for authorizing us to work directly with concessions and with non-profit organizations. Specifically, we have concluded that we could use limited concession authority within our primary mandate of resource protection to control, limit, or redirect certain activities in our marine sanctuaries.

These activities may cause adverse ecological effects on sanctuary resources and are not appropriately or easily addressed through our existing regulatory or enforcement programs.

In other areas, in terms of research and education, we believe the use of cooperating associations is probably a better mechanism than concessions to accomplish sanctuary program objectives. These are authorities the National Park Service has had for over 40 years.

And finally, we would like to see that we have the power to accept gifts of property and money to enhance on-site and program-wide operations, again similar to that the Park Service operates with.

And I will conclude with that statement and be happy to answer any questions.

Senator KERRY. I think that last makes a lot of sense. The concession thing, what did you call it? You acknowledged that it could have some adverse impacts.

Mr. URAVITCH. It depends on what the specific activity is that is going to take place.

Senator KERRY. What sort of activities would you envision?

Mr. URAVITCH. There are a number of private activities that we see taking place in sanctuaries now: whale watching on the West Coast, dive boats, glass-bottomed boats in Key West. There have been a couple proposals for an underwater hotel.

There are all sorts of activities which are proposed or are already operating within the boundaries of our sanctuaries, and what we would like is some direct authority to review these particular activities and come up with some means to regulate or control them on a systematic basis. And, when there is a proposal, to analyze it and determine whether there is a potential environmental impact and whether it should be allowed or not allowed, based on whether the activity is going to help or harm the resources of the sanctuary.

Senator KERRY. Do you think that would be plausible to have that power?

Mr. URAVITCH. Yes, sir, I do, because we already see in the case of Key Largo a large number of private sector activities such as dive boats taking place.

And one of the issues we are looking at is how we control, for example, the amount of boats that will be dropping divers on one particular reef. And we are going to have to get some handle on that.

If we have, say, 10 boats going to one reef and one boat going to another, we feel we need some authority to maybe spread that use out throughout the sanctuary and reduce stress on the reef.

Senator KERRY. Now, as you know, some people have raised the issue about the rate at which sanctuaries have been designated. There was a change in the law in 1980, 1984, and people feel the process has been pretty slow.

Why have so few sites been designated in the last few years?

Mr. URAVITCH. I would say there are two reasons. One is that we have been focusing mainly on trying to get the existing sites operational.

We designated four new sites in 1980 and 1981. We have had to put a considerable amount of resources and people out there on site. Essentially we have just been trying to develop and manage that system in a systematic way.

The balance of our resources have been applied specifically to three new sites currently in development and three additional candidates. There has been a considerable amount of work done on sites that were never designated for various reasons, the whale sanctuary in Hawaii being one, La Parguera in Puerto Rico being another, Monterey Bay being a third. And in most cases what we had is significant local opposition.

So we have really been working on the designation of six additional sanctuaries, but three of them have fallen by the boards, for one reason or another.

Senator KERRY. But now given that fact, and I take it on its face that that is the problem, the outlays for last year were $2.6 million. And I gather that you have requested a cut in funding this year.

Mr. URAVITCH. Yes, sir.

Senator KERRY. How are you going to plan to expand the sanctuary program and speed up the process of site selection when you are already stretched in resources and you are asking for less money?

Mr. URAVITCH. There are really two processes at work. One is site designation, and we are in the process of doing that now, and the other is on-site operations.

And I believe with some new staff, I have authority to hire three additional people, that we will be able to deal with new site designations at a reasonable rate. The balance will be done by essentially shifting resources in some cases.

Cordell Bank, which will be designated in California, is adjacent to the existing Farallones Sanctuary. So we will run it out of our Gulf of Farallones area. So there will just be a marginal, incremental increase in operational costs.

Senator KERRY. Can I ask you, what was your request to the Commerce Department for the program?

Mr. URAVITCH. For which, sir?

Senator KERRY. What was NOAA's request for funding to the Commerce Department?

Mr. URAVITCH. For fiscal year 1989? I believe it was $2.3 million.

Senator KERRY. $3.3 million?

Mr. URAVITCH. Yes.

Senator KERRY. That was your request?

Mr. URAVITCH. Yes, sir.

Senator KERRY. What aspects of the program do you think are most likely to suffer as a result of that?

Mr. URAVITCH. What we have lost essentially over the past couple of years have been projects in specific sanctuaries related to research activities.

What we have been focusing on is basically operations, enforcement, and protection of the resource. And dealing with basic public education activities in conjunction with museums, sea centers, and the like. And when we make our changes, those are usually done in the research areas.

Senator KERRY. Is there a qualitative loss to the program as a result of that?

Mr. URAVITCH. What we lose is the ability to directly target specific issue areas that we might like to address as a problem in a specific sanctuary.

Senator KERRY. Does that affect at all the site selection process?

Mr. URAVITCH. No, sir, it does not.

Senator KERRY. Does it affect the protection enforcement aspects?

Mr. URAVITCH. Well, like anybody, we could always use a few more people somewhere. But generally, I think we have been doing an adequate job.

The main enforcement areas where we have problems are in Key West in Florida where we have the, or Key Largo, excuse me, with the largest visitation. And we have managed to increase our contracted enforcement officers down there.

Senator KERRY. How many more sites do you see designating by 1990?

Mr. URAVITCH. By 1990, we will have done at least the three that we are working on, Flower Gardens, Cordell, and Norfolk Canyon.

We will have begun work, my guess is, on at least two additional natural resource sites. And I would hope we would have at least one more historic and cultural site designated.

Senator KERRY. Are there any areas you are aware of that are particularly threatened that might call for more rapid designation or immediate attention?

Mr. URAVITCH. There are a couple areas that we have had a lot of public input on. Essentially, the reef areas in southern Florida have been pointed out to us as areas under considerable stress. And unfortunately, they are outside our site evaluation list.

So that is one of the reasons why we are opening up the list to consider whether to put those areas on there. We intend to start this process by July, hopefully getting the SEL out within the next couple months after that, so that we can start getting some public input on those stressed areas.

We will also be working with other parts of NOAA which have been doing the EEZ mapping and other strategic assessment work, to try and use their data to determine those areas that are heavily stressed and also show high biological productivity, to see if that is another way of determining better the locations for new sites.

Senator KERRY. Well, what I would like to do is, also in your case, Mr. Uravitch, leave the record open so that if staff or I have any additional questions that we need to follow up on we can do that.

I also want to say that the record will be open for the addition of submissions from various groups in support of the reauthorization, and those will be included at the appropriate time.

Is there any additional comment that you wish to make with respect to the reauthorization process?

Mr. URAVITCH. No, sir. I appreciate your help.

Senator KERRY. Well, we care about the program. And my biggest concern is that we are not selecting sites fast enough or capable of being as protective as we would like to be. But I understand there are difficult financial restraints on everything right now, and it is hard.

But I think the Committee is obviously disposed to try to see you have what you need to be able to continue forward. Thank you very much. The hearing stands adjourned.

[The statement follows:]

STATEMENT OF JOSEPH A. URAVITCH, OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMENT, NATIONAL OCEAN SERVICE, NOAA

Mr. Chairman and members of the Committee, I am Joseph Uravitch, Chief of the Marine and Estuarine Management Division, National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce.

In 1984, we last appeared before this Committee to discuss reauthorization of Title III of the Marine Protection, Research, and Sanctuaries Act of 1972, which is the legislative authority for our National Marine Sanctuary Program. Since 1984, we have designed a seventh National Marine Sanctuary, the Fagatele Bay in American Samoa; are in the process of designating three additional sanctuaries (Cordell Bank, Flower Garden Banks, and Norfolk Canyon); and have made substantial progress in improving our management of the sanctuaries. A description of the existing seven sanctuaries and the three in the process of designation is attached to my written statement.

REAUTHORIZATION

The Administration supports reauthorization of Title III at a level of $2,325,000 for FY 1989 and such sums as may be necessary for FY 1990.

The Secretary of Commerce transmitted to the Congress on May 4 a draft legislative proposal that would reauthorize Title III at the levels I have indicated and make two amendments regarding enforcement. The first amendment would restore authority under Title III to the Secretary of Commerce to enter into enforcement agreements on a nonreimbursable basis, and to enter into enforcement agreements with State agencies. These powers were omitted when Title III was amended in 1984. The second amendment would empower authorized Federal and State enforcement officers to conduct searches, seize vessels, resources, and other items used or taken in violation of Title III and its implementing regulations, seek the forfeiture of seized items, pay storage costs of seized items, and pay rewards for information about violations. Such provisions are consistent with other resource statutes enforced by the Secretary, such as the Magnuson Fishery Conservation and Management Act.

FUTURE DESIGNATIONS

We have three sites under active consideration for designation as national marine sanctuaries. As you are aware, the 1984 amendments to Title III revised the designation standards and procedures. Generally, the 1984 amendments improved the program by strengthening affected public and Federal agency involvement and clarifying designation procedures. Because we are applying the revised designation standards and procedures to all new sites, including those that are presently in the designation process, there has been some delay in our designation actions while we revised our designation regulations to comply with the 1984 amendments.

We are designating new sanctuaries at a pace which will allow us to integrate new sites into a well-managed national marine sanctuary system. Assuming favorable public comment, we intend to designate one new national marine sanctuary per year in 1988, 1989 and 1990, with on-site operations beginning in the following year.

Cordell Bank, in Federal waters twenty miles west of Point Reyes, California, should be designated by the end of 1988. We are now preparing the Final Environmental Impact Statement (EIS) and Management Plan in response to the nearly 200 comments received on the Draft EIS. Because of the proximity of the existing Gulf of the Farallones Sanctuary to the proposed Cordell Bank Sanctuary, we will jointly manage and operate these sanctuaries, alleviating the need for additional funds.

We plan to designate the Flower Garden Banks National Marine Sanctuary in 1989. The preliminary Draft EIS and Management Plan for this coral reef complex, located 115 miles south of the Texas/Louisiana coast, is under review within NOAA and should be available for public comment in July 1988. -Name: -Folios: 193–195 - Date: 10–11–88 -Subformat:

We have already held the scoping meeting and are currently preparing the draft EIS and Management Plan for the Norfolk Canyon National Marine Sanctuary, 60 nautical miles off the Virginia coast. Designation is anticipated for late 1989 or early 1990.

Regarding the issue of sanctuary designation beyond the seven already in existence and the three in progress, our next candidate will be selected from the Site Evaluation List (SEL), first developed in 1983. However, because we have seen little or no active State interest or support for designation of new candidates since 1984, and because the SEL is old, we will reopen it for public comment prior to making a selection. We intend to seek public comment soon after August 1988, meeting the five-year reevaluation cycle required by our regulations.

Based solely on developing a geographically representative system for the natural resources component of the National Marine Sanctuary Program, the most likely candidates should come from northeastern, northwestern, Great Lakes or Caribbean waters of the United States. However, our decision will be based on the resource most in need of immediate Federal management and protection.

As you know, the 1984 amendments added cultural and historical resources to the list of factors to be considered in designating sanctuaries. There is a need to protect marine historical and cultural resources of national significance through designation of national marine sanctuaries. However, how we proceed and the level of protection we can provide to these resources depends to some degree on Congressional action to provide the Secretary of Commerce with additional authority. In our comments on the recently enacted abandoned shipwreck legislation, we recommended either United States retention of title to shipwrecks of special national significance or some other full protection mechanism. This issue remains very important to the sanctuary program.

In response to the 1984 amendments, we are developing a separate SEL for historical and cultural resources, such as the U.S.S. MONITOR. Public support of such activities is amply demonstrated by the more than 1,000 letters we received from citizens across the United States in response to the Sunday, December 20, 1987 article on the MONITOR National Marine Sanctuary which appeared in *Parade Magazine*. We have been proceeding cautiously, but deliberately, in the area of cultural resources because of the need to test new technology and methodology, as well as the possibility of breaking new legal ground.

IMPROVING PROGRAM OPERATIONS

Since 1984, we have made significant improvements in resource management using our existing authority. For example:

1. We have almost completed the standardization of the penalty schedules for violations of the regulations governing each sanctuary. Five of the seven sanctuaries

now have standardized minimum and maximum penalties for similar violations in each sanctuary. Each penalty collected goes to the United States Treasury.

2. We have supported sanctuary operations on the East and West Coast by hiring on-site staff necessary to protect the resources, assist researchers, and educate the public. We also have developed an on-site emergency response capability, which we have used in emergencies ranging from ship groundings to aiding a diver having a heart attack.

We are reviewing sanctuary operational procedures, regulations and enforcement, monitoring, and research and educational activities to determine where standardization can result in improved, cost-effective management of the resources. We believe the public deserves, and the resources are better protected by, a clear, predictable decision-making and management process.

Specific actions currently in process to improve our resource management capabilities include:

1. Development of efficient research and education programs, comparable to those operating or under development in our National Estuarine Research Reserve System, which identify site specific and national priorities; provide a clear and predictable process for project submission, review and funding; and produce work products of value in managing our Nation's marine resources.

2. Review of the on-site regulations of existing national marine sanctuaries to ensure that comparable activities are handled in a similar manner throughout the national program.

3. Development of an on-site sanctuary manager's operations manual. The program has reached the point where economics and simple good management require that routine activities, such as accounting procedures, policies on organizing symposia, response to groundings and resulting damage assessments, are handled in a similar fashion throughout the program.

4. Review of the resources and regulations of existing sanctuaries to detrmine if we can better protect historical and cultural resources of national importance located within them. Actions such as these must occur before the system is expanded beyond its current size.

NEED FOR CONCESSION AND OTHER AUTHORITY TO WORK WITH THE PRIVATE SECTOR

We have considered the need for authorizing concessions in national marine sanctuaries and conclude that limited concession authority would be desirable within our primary mandate of resource protection to control, limit, or redirect certain activities in national marine sanctuaries. Activities that may cause adverse ecological effects on sanctuary resources and are not appropriately or easily addressed through regulatory or enforcement programs are particularly suited for management through concession agreements.

In the areas of research and education, we believe the use of cooperating associations is a better mechanism than concessions to accomplish sanctuary program objectives. The National Park Service has had such authority for over 40 years. Finally, providing the program with the power to accept gifts of property and money would enhance operations on-site and program-wide. As with authority to designate cooperating associations, the Park Service has had this authority for a number of years.

CONCLUSION

In conclusion, we believe that our work during these times of ever tightening budgets has been effective. As the more than three quarters of a million 1987 visitors to Key Largo can attest, including resource managers from other countries who come to us for training, we are educating the public and protecting, managing, and undertaking research on the resources—activities we look forward to continuing in the coming years.

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ATTACHMENT TO TESTIMONY FOR THE REAUTHORIZATION OF TITLE III

DESCRIPTION OF DESIGNATED NATIONAL MARINE SANCTUARIES

Monitor National Marine Sanctuary.—A one square nautical mile area surrounding the wreck of the historic Civil War ironclad, the *U.S.S. Monitor.* Designated in 1975, this was the nation's first National Marine Sanctuary. Several innovative designs gave the *Monitor* a tactical advantage over conventional broadside warships. She is popularly credited with revolutionizing naval warfare and saving the Union Navy during the famous battle of the ironclads off Hampton Roads, Virginia, in 1862.

Gray's Reef National Marine Sanctuary.—A 17 square nautical mile area protecting a limestone outcrop supporting a rich community of sponges, soft and hard corals, sea turtles, tropical reef fish, and invertebrates. Designated in 1981, Gray's Reef occurs in a transition zone between the warm Gulf Stream and more temperate coastal waters. Located in relative isolation 17.5 nautical miles offshore Georgia, this site presents different management problems from the more populated sites in Florida.

Key Largo National Marine Sanctuary.—A 100 square nautical mile area off the Florida Keys encompassing a spectacular portion of the largest coral reef system off North America. Designated in 1975, the Sanctuary is adjacent to the John Pennekamp Coral Reef State Park, and receives hundreds of thousands of visitors every year. Activities include fishing, skin and scuba diving, and sightseeing from glass bottom boats.

Looe Key National Marine Sanctuary.—A 5.3 square nautical mile reef area located 6.7 miles offshore the lower Florida Keys. Designated in 1981, the site protects a classic example of the Florida reef-tract "spur-and-groove" formation. Like Key Largo, this site is heavily used by skin and scuba divers, commerical fishermen and boating tourists.

Channel Islands National Marine Sanctuary.—A 1,252 square nautical mile area located off the southern California coast. Designated in 1980, this site supports one of the largest and most varied assemblages of marine mammals in the world. It also provides refuge for a diverse concentration of pinnipeds (seals and sea lions), and includes the most extensive kelp beds remaining in southern California.

Gulf of the Farallones National Marine Sanctuary.—A 948 square nautical mile area northwest of San Francisco, encompassing a wide variety of offshore and nearshore habitats characteristic of the northeastern Pacific. Designated in 1981, this site provides food and nesting habitat to a large and unique concentration of seabirds. Whales, porpoises, and pinnipeds also are abundant.

Fagatele Bay National Marine Sanctuary.—A 163 acre bay off Tutuila Island, American Samoa. Designated in 1986, the Sanctuary contains deep water coral terrace formations unique to the high islands of volcanic origin in the tropical Pacific, and offers the opportunity to investigate reef management problems such as crown-of-thorns starfish (*Acanthaster*) infestation.

ACTIVE CANDIDATES FOR DESIGNATION

Cordell Bank.—An 18.4 to 397 square nautical mile area of Federal waters adjacent to the northern boundary of Gulf of the Farallones National Marine Sanctuary is under review by NOAA. Designation of this northernmost seamount is planned for FY 1988; the Final Environmental Impact Statement and Management Plan is being prepared. The area is noted for its wide variety of bottom organisms, unusual number of finfishes, marine mammals and seabirds.

Flower Garden Banks.—This 44 square mile site is located 115 miles south of Galveston, Texas. The Banks represent the northernmost shallow-water tropical coral reef community in the Gulf of Mexico. A Draft Environmental Impact Statement and Management Plan should be released in the summer of 1988, with designation planned for FY 1989.

Norfolk Canyon.—This deepwater submarine canyon is located approximately 60 nautical miles off the Virginia coast. The site supports an abundance of marine life including tree corals and "pueblo village"-like invertebrate and finfish communities. A scoping meeting was held in June 1986 and a Draft Environmental Impact Statement and Management Plan is being prepared. Designation is planned for FY 1990.

[Whereupon, at 12:16 p.m., the hearing was adjourned.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

Statement of Leslie A. Carothers, Commissioner, Connecticut Department of Environmental Protection

The recent report published by the Environmental Defense Fund (EDF) "Polluted Coastal Waters: The Role of Acid Rain" underscores the need for multidimensional investigation of environmental issues. The time when individual sources could be studied and managed exclusive of other influences has passed, particularly in marine environments which receive a regional or even global mix of contaminants. While control of individual point sources is a more cost-effective way of reducing contaminant loads, we must be sure that when goals for improving water quality dictate, non-point sources receive adequate attention.

In the case of Long Island Sound, the role of atmospheric deposition has not gone unnoticed. The Long Island Sound Study (LISS), which the State of Connecticut actively participates in, has identified periodically severe hypoxia (low dissolved oxygen) in the western portion of the Sound. Current belief is that the levels of nitrogen released to the Sound may exacerbate this condition. To describe the dynamics of hypoxia and to develop an effective management plan to control the problem, the study is funding development of a water quality model. Atmospheric deposition is a component of the model. Only upon completion of the model will we know how best to treat the condition and how deep the cuts into non-traditional sources, such as atmospheric loads, need to be.

The state of knowledge on the role of atmospheric deposition is not complete at this time as was acknowledged in the EDF report. Estimates are based on weak databases and the processes once wet and dryfall hit the earth are poorly described. The EDF estimates for Long Island Sound focus on the deposition of the nitrate component of rainfall as it is the form most relevant to the contribution of fossil fuels. Their estimate of atmospheric nitrate loading was 23 percent of the total nitrogen load to Long Island Sound when compared to NOAA's National Coastal Pollutant Discharge Inventory (NCPDI). Our reports from 1985 and 1986 on the contribution of nitrogen compounds (including ammonium and organic nitrogen) falling directly on the Sound range from 8 to 19 percent of the total load. These estimates were calculated using loading rates taken from the literature. They differ from the EDF estimates because of the different nitrogen forms used to compile the estimates, and the inclusion of deposition on the land area draining into Long Island Sound by EDF. If our 8 to 19 percent of the total load. These estimates were calculated using loading rates taken from the literature. They differ from the EDF estimates because of the different nitrogen forms used to compile the estimates, and the inclusion of deposition on the land area draining into Long Island Sound by EDF. If our 8 to 19 percent estimate is revised to include only the nitrate component, the percentages would be about one-third less. The nitrate load from our estimates would then be comparable to EDF's calculation of 3.1 million kg/yr of direct deposition of nitrate on the Sound.

However, the nitrate loading rate may vary widely geographically. Rainfall samples taken by U.S.G.S. at wetfall monitoring stations in Connecticut in 1981 through 1983 averaged only 0.144 mg NO_2 + NO_3-N/L. This is less than the literature rates used by both EDF and ourselves. Applying this value for an average annual rainfall of 115 cm and the surface area of Long Island Sound, the nitrite and nitrate load would be only about 0.6 million kg/yr. Even doubling this value to estimate dryfall would yield les than half the load reported by EDF. Clearly there is much uncertainty to be resolved.

The watershed deposition values reported by EDF are even more problematic due to uncertainties about processes during transport. The Long Island Sound drainage is large, extending to Canada in the north. We would not expect a delivery rate to Long Island Sound from that distance to be equivalent to what would be seen from areas on the coast. Whether the test drainages upon which EDF bases their 19 percent delivery rate estimate reflect adequately transport processes in the Long Island Sound basin is subject to discussion. In a large basin, only a small error in delivery rate would result in significant differences in loading estimates. Meteorological variability, land use and season will undoubtably complicate the issue..

Regardless of the inherent uncertainties briefly reviewed above, it is clear that the atmospheric portion of nitrate loading is significant and must be accounted for. This information will be key to the development of realistic management plans. The recommendations in the EDF report calling for clear definition of the problem and national regulations to reduce nitrogen oxide emissions are sound ones and likely to yield positive benefits towards the goal of achieving good water quality in our nation's marine systems.

Center for
Environmental
Education

1988 JUN 15 AM 9:41

10 June 1988

Honorable Ernest F. Hollings
Committee on Commerce, Science and
Transportation
508 Senate Dirksen Office Building
Washington, D.C. 20510

Dear Senator Hollings:

Thank you for providing us with the opportunity to submit written testimony regarding reauthorization of Title III of the Marine Protection, Research and Sanctuaries Act. I ask you permission to include this letter in the record of the Committee's hearing on this program.

First, I wish to note that several organizations have endorsed my written testimony since it was submitted. These are American Oceans Campaign, Coast Alliance, Defenders of Wildlife, and Natural Resources Defense Council.

Second, I wish to add an important note to my written remarks about concessions within national marine sanctuaries. A concession activity in a sanctuary should be permitted only if it will not pose a threat to sanctuary resources. To do otherwise would be inconsistent with the basic emphasis of the program: conservation of nationally significant resources. To insure consistency, permits should be granted only after a full environmental assessment of the activity has been conducted and subjected to public review.

Third, funding for this program has become a critical matter. Since 1984, the operating budget of the program has been cut 20 percent. This reduction is disproportionate to that suffered by most other marine programs in the last several years. The pressures against raising appropriations for any program are particularly acute this year. And while these pressures may abate by 1990, they will not disappear. There is, therefore, both a short-term and a long-term budget problem for this program. I wish to suggest partial solutions at least for both problems.

First, the demonstrated inability of NOAA to review and designate new sanctuary sites has been caused by a lack of staff to a large extent. I understand that this lack of staff is not entirely due to budget reductions but to the reassignment of national marine sanctuary positions to the estuarine research reserve program. The estuarine reserve program currently includes three times as many sites as the

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marine sanctuary program. I suggest that the time has come for the estuarine program to curtail growth temporarily while the marine sanctuary program expands.

The Center for Environmental Education has supported the estuarine research reserve program for many years. The program should continue to consolidate its gains of the last several years. But we must urge that you act to return staffing to the national marine sanctuary program from the estuarine research reserve program.

In the future, funding for the national marine sanctuary program and for the estuarine research reserve program must increase in a stable and secure fashion if they are to provide their unique benefits of protecting outstanding marine areas and of providing natural laboratories for marine and coastal research and education. Both programs have already contributed to our ability to conserve coastal resources such as coral reefs and salt marshes.

With this in mind, I suggest that the repayment of loans to states under the Coastal Energy Impact Program (CEIP), authorized by Section 308(h) of the Coastal Zone Management Act (CZMA), be transferred without appropriations from the Coastal Energy Impact Fund (CEIF) to a new Coastal Protected Areas Fund. In rough order of priority, allocations from the fund should be devoted to general operation of the two programs, to management of existing marine sanctuaries and identification of new sites, to research and education in current estuarine research reserves, and to identification and acquisition of new estuarine areas.

Between 1978 and 1983, eight states received loans under CEIP totalling $128,448,000. The 1984 amendments to the CZMA ended the loan program effective September 30, 1986. The states have been gradually paying back the principal and interest; these repayments are deposited initially in the CEIF, then transferred into the General Treasury. Annual payments of seven to ten million dollars are expected for the next 20 years.

As I mentioned above, the use of funds from the CEIF for marine sanctuaries and estuarine research reserves is appropriate particularly because the management, research, and education activities at existing sites have already advanced the conservation and public enjoyment of coastal resources. For example, more than one million people visit the Key Largo National Marine Sanctuary each year. A mooring buoy system developed at that sanctuary is helping protect coral reefs in other areas as well. Primary, secondary, and university educational institutions regularly use estuarine and marine sites of these two programs.

I urge your consideration of establishing the Coastal Protected Areas Fund and authorizing the transfer of CEIF repayments into that fund without appropriations beginning in 1990. With this stable, but modest source of funds, the national marine sanctuary programs and the estuarine research reserve program will be able to fulfill their potential for many years to come.

Thank you for considering these additional remarks.

Sincerely,

Mike Weber

Michael Weber
Vice President for Programs

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